NATURE

A Weekly Journal of Science

Vol. 187, No. 4736 SATURDAY, AUGUST 6, 1960 2s. 6d.

THE UNIVERSITY OF MICHIGAN
SEP 7 1960
UNDERGRADUATE LIBRARY

Announcing

MSE 'SUPER-SPEED 40' CENTRIFUGE

Maximum Speed:
40,000 r.p.m.
(= 176,000 × g)

★ Electronically controlled automatic operation

★ Extensive range of angle and swing-out rotors

★ A number of unique safety features

★ Built-in vacuum and refrigeration units

MSE

GD 353

MEASURING & SCIENTIFIC EQUIPMENT LTD.

Spenser Street, London S.W.1. Telephone: VICtoria 5426

VACUUM NOTES—LEAK DETECTION NO. 9

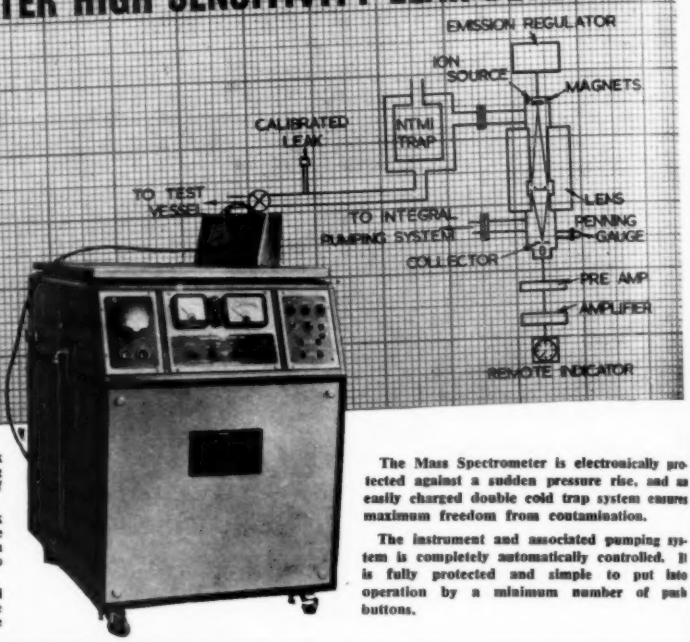
MASS-SPECTROMETER HIGH SENSITIVITY LEAK DETECTION

ULTRA HIGH SENSITIVITY

EASILY TUNED FOR USE WITH HYDROGEN OR HELIUM

ELECTRONICALLY PROTECTED FOOLPROOF IN OPERATION

NEW TYPE LENS FOCUSING SYSTEM



The model LT7 Mass Spectrometer leak detector unit has a unique axial lens focusing system giving a high sensitivity in the order of 5×10^{-7} lusecs for hydrogen.

An accurately calibrated reference leak enables immediate sensitivity checks to be made. A readily accessible ion-source has a spare filament which can be switched into circuit by a front panel control.

Leaks are indicated on a robust moving coil meter housed in a portable unit which can be sited in any desired position away from the main instrument.

The Mass Spectrometer is electronically protected against a sudden pressure rise, and an easily charged double cold trap system ensures maximum freedom from contamination.

The instrument and associated pumping system is completely automatically controlled. It is fully protected and simple to put into operation by a minimum number of push buttons.

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY | SUSSEX | Crawley 1500

AROUND THE WORLD IN 80 ~~DAYS~~ *hours*!

This is not just a saying at NBCo. Our organization is geared to process all orders so that biochemicals will be delivered anywhere in the world to arrive within 80 hours or less. Naturally, orders in the U.S. will arrive within 24 hours. Our tremendous stocks of the purest biochemicals sell at the lowest prices and include over 300 Amino Acids • Over 90 Peptides • Over 200 Nucleoproteins, Purines, Pyrimidines • Miscellaneous Biochemicals • Vitamins • Enzymes-Crystalline, Purified • Growth Factors • Steroid Hormones • Biological Salt Mixtures and Test Materials • Carbohydrates • Purified Proteins • Fatty Acids • Antibiotics • Alkaloids • Glandular Substances.

SEND FOR OUR FREE JULY, 1960 CATALOG

Containing more than 2600 items. Fill out coupon and mail today for your copy.

NAME_____

ORGANIZATION_____

ADDRESS_____

CITY_____

STATE_____ ZONE_____ (No.)

NUTRITIONAL BIOCHEMICALS CORPORATION

21010 MILES AVENUE • CLEVELAND 28, OHIO

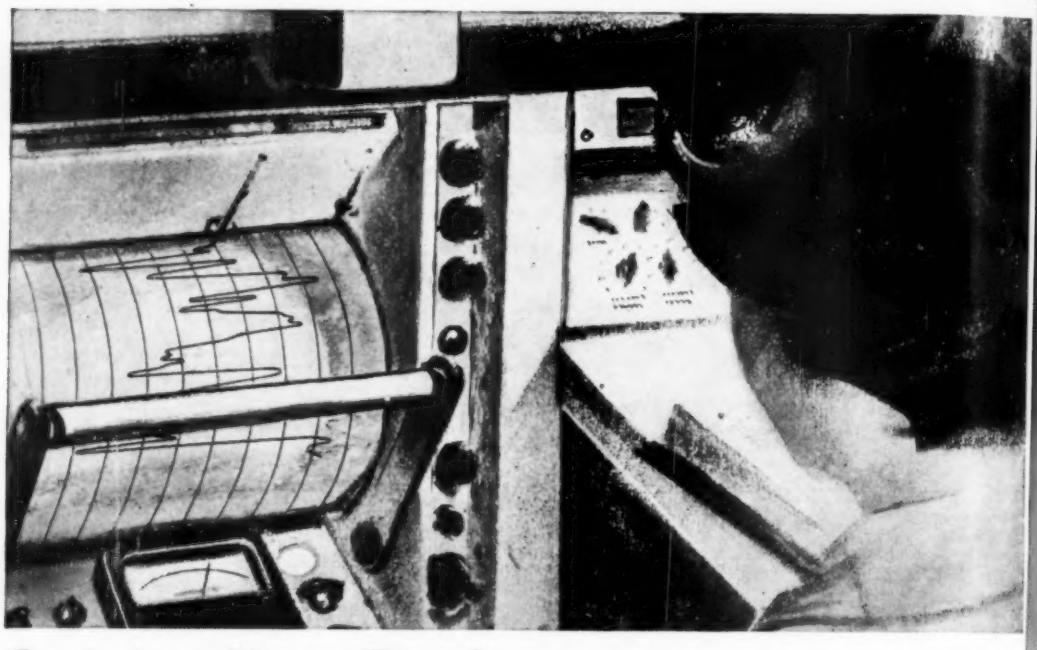
NATURE

No. 4736 SATURDAY, AUGUST 6, 1960 Vol. 187

CONTENTS

	Page
Educational Co-operation in the Commonwealth	441
The Galathea Expedition. By Dr. N. B. Marshall	443
Stability and Control of Flight	444
Reference Book of Theoretical Physics. By Prof. R. Eisenschitz	445
Evolutionary Divergence. By C. S. Elton, F.R.S.	446
The Two Heredities. By Dr. J. D. Nisbet	446
Biochemistry and Heredity. By Dr. P. Cohn	447
Recent American Research in Neuropsychiatry. By Dr. D. H. Brinton	447
Advances in Veterinary Science. By Prof. H. Burrow	448
Flora of the Zambesi Basin. By A. A. Bullock	449
Cells and their Environment. By Dr. E. N. Willmer, F.R.S.	450
The International Co-ordination of Time Signals and Standard Frequency Transmissions. By Dr. L. Essen, O.B.E., F.R.S.	452
The National Physical Laboratory. By H. G. Short	454
Final Months and Descent of Satellite *Sputnik* 3. By B. R. May and D. E. Smith	456
Scientific Research and Development: a Comparative Study. By S. Dedijer	458
Measuring the Size of Isolated Cells. By Dr. Samuel S. Epstein and Jacqueline B. Weiss	461
News and Views	463
The John Innes Institute. By Dr. K. S. Dodds	467
The World Health Organization	468
The Metropolitan Water Board. By Dr. B. A. Southgate, C.B.E.	468
East African Fisheries Research Organization. By H. C. Gilson	469
U.S. Materials Research and Development for National Security	470
Education and Industry	470
Training in Radiological Health and Safety. By Prof. J. E. Roberts	471
Localization by Autoradiography at — 195° C. of Radioactive Areas in Rats exposed to a High Flux of Thermal Neutrons: Importance of Phosphorus-32 in Consecutive Internal Irradiation. By Jean Chanteur and Pierre Pellerin	472
Effects of Linear Energy Transfer on the Radiolysis of Water and Heavy Water. By Dr. E. Collinson, Prof. F. S. Dainton, F.R.S., and J. Kroh	475
Orienting Effects in Octahedral Aquation. By Sir Christopher Ingold, F.R.S., Prof. R. S. Nyholm, F.R.S., and Dr. M. L. Tobe	477
Fall-out Cæsium in Surface Sea Water off the California Coast (1959–60) by Gamma-Ray Measurements. By Dr. Theodore R. Folsom, Dr. G. J. Mohanrao and Perrin Winchell	480
Viscosity Increments of Non-Ionized Molecules. By Alfred Polson	482
Amino-Acid Sequence of Human Insulin. By Dr. D. S. H. W. Nicol and Dr. L. F. Smith	483
Mechanism of Formaldehyde-induced Mutagenesis. The Uniqueness of Adenylic Acid in the Mediation of the Mutagenic Activity of Formaldehyde. By Dr. Thomas Alderson	485

(Continued overleaf)



Outstanding Performance
....now further enhanced

Infrared instrumentation reaches its highest peak in the latest example of the Unicam SP.100 Infrared Spectrophotometer. Its exceptional performance, based on the correct physical principles employed in its design, has been further enhanced by accumulated experience from the many Unicam infrared spectrophotometers now in use. The result is a combination of high resolution, extreme quantitative accuracy, speed and reliability hitherto unattained in one instrument.

Spectroscopists and chemists seeking the highest standards of qualitative and quantitative analysis can obtain the most detailed information in the shortest time by means of this easily operated, versatile and powerful spectroscopic tool.

Sales and service facilities are now available in many parts of the world. Full information will gladly be sent on request.

Facts that speak for themselves

Resolution with grating-prism combination 0.3 cm^{-1} at 900 cm^{-1} and 1.5 cm^{-1} at 3,000 cm^{-1}.
With NaCl prism 1 cm^{-1} at 900 cm^{-1}.

Accuracy: routine quantitative intensity measurement at high resolution at 0.1% accuracy down to at least 2% transmission level.

Stray Light: better than 0.1% at 650 cm^{-1} (grating-prism combination).

Reproducibility: transmission—better than $\pm$0.2%. Wavenumber—better than 0.5 cm^{-1} at 1000 cm^{-1}.

Versatility: wide range of operating variables allows ideal conditions to be selected for every analytical problem. The rotating prism and grating turntables provide for automatic interchange of the optical system. Vacuum conditions for the optical train eliminate unwanted absorptions.

Reliability: correct design, high quality of construction, plug-in electronic chassis, built-in safety devices and monitoring system prevent accidental damage and ensure long-term reliability.

UNICAM SP. 100 Infrared Spectrophotometer

UNICAM INSTRUMENTS LIMITED · ARBURY WORKS · CAMBRIDGE

U193

LETTERS TO THE EDITORS

Page

ASTRONOMY

Roughness of the Moon as a Radar Reflector.—Dr. B. H. Briggs 490

GEOPHYSICS

Evaluation of the Second, Fourth and Sixth Harmonics in the Earth's Gravitational Potential.—D. G. King-Hele 490

Oscillatory Character of Amplitude Curves for Seismic Body Waves.—Dr. J. Vaněk and J. Stelzner 491

PHYSICS

Speed of the Superconducting-Normal Transition in Tin Films.—D. J. Oliver, M. J. Rayner and E. H. Rhoderick 492

Strengths of Acid-etched Glass Rods.—B. A. Proctor 492

Stimulated Optical Radiation in Ruby.—Dr. T. H. Maiman 493

METALLURGY

A Simple Method of investigating the Creep of Metals under Simple Shear.—Prof. E. N. da C. Andrade, F.R.S. 494

An Improvement in the Ductility of Beryllium at High Temperatures.—A. Brown, F. Morrow and A. J. Martin 494

Hexagonal Modification of Black Chromium Electro-deposit.—Hideya Okada and Takeo Ishida 496

GEOLOGY

Stability of Epidote Minerals.—Prof. W. S. Fyfe 497

Relic-Soil on Limestone in South Wales.—D. F. Ball 497

CRYSTALLOGRAPHY

Crystal Growth in Paraffin.—R. J. Jaccodine . 498

Five Co-ordinated Titanium in $K_2Ti_2O_5$.—Dr. Sten Andersson and Dr. A. D. Wadsley . . 499

CHEMISTRY

Ultra-violet Absorption Spectra of the Diazines.—Prof. K. Keith Innes, James A. Merritt, Wayne C. Tincher and Shelby G. Tilford . . . 500

Initial Stages of Oxidation of Coal.—S. K. Chakrabartty, B. K. Mazumdar and A. Lahiri . 502

Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces.—A. M. Peers ; Dr. E. A. Blomgren and Dr. J. O'M. Bockris 503

Structure of the Trinuclear Basic Acetates.—Dr. L. E. Orgel 504

Positions of Thorium and Uranium in the Periodic Table.—Dr. A. E. Dwight 505

BIOCHEMISTRY

Phosphoproteins and Mitochondrial and Cell Water.—Dr. J. D. Judah 506

Protection against Liver Injury due to Murine Hepatitis Virus.—Dr. J. D. Judah, G. Bjotvedt and T. Vainio 507

Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the Cell Nucleus.—Dr. E. A. Barnard and Dr. L. G. E. Bell 508

Reversible Dissociation of Ribonucleic Acid.—R. A. Brown, K. A. O. Ellem and Dr. J. S. Colter 509

Carbohydrates of *Ecklonia radiata*.—C. M. Stewart and H. G. Higgins 511

Page

Fatty Acid Composition of the Lipids of Pasture Grasses.—Dr. G. A. Garton 511

PHYSIOLOGY

A Biological Interval Analyser.—G. K. Smith and B. Delisle Burns 512

Depressing Activity of Meprobamate on the Reticulo-Endothelial System.—Prof. A. Del Vecchio and L. Bolis 513

Anti-Fertility Action of a Monoamine Oxidase Inhibitor.—W. G. Spector 514

Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism).—Dr. Herman Zondek, Dr. Hannah E. Leszynsky and Dr. Joseph A. Stein 515

Effect of Wheat Gluten on the Peristaltic Reflex.—Dr. R. Schneider, H. Bishop, Dr. B. Shaw and Prof. A. C. Frazer 516

HÆMATOLOGY

Substance from Erythrocytes of Blood Group A.—J. Koscielak and K. Zakrzewski . . . 516

Haptoglobin Types in 398 Blood Donors from Dakar (Senegal).—Dr. J. Moullec, Dr. J. M. Fine and J. Linhard 517

BIOLOGY

Translocation of Wild Animals as a Means of Game Control.—Dr. A. M. Harthoorn, J. A. Lock and J. MacKeand 518

Effect of Penicillin on the Maintenance of Rumen Oligotrich Protozoa.—G. S. Coleman . . 518

Protandry and Self-Fertilization in the Calyptraeidae.—Dr. H. V. Wyatt 520

Suppression of Cytoplasmic Division in *Amoeba proteus*.—Dr. Edmund Guttes and Sophie Guttes 520

Albinism in an American Population of the Shore Crab, *Carcinus maenas* (L.).—Anthony J. Provenzano, jun. 521

Chordotonal Organs in Crustacea.—Dr. Mary Whitear 522

Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves.—Dr. Malcolm B. Wilkins 523

ENTOMOLOGY

Recognition of Nulliparous Mosquitoes without Dissection.—Dr. Philip S. Corbet . . . 525

Ovarioles as a Meristic Character in Coleoptera.—Dr. J. G. Robertson 526

Nutritive Values of Carbohydrates for the Silkworm, *Bombyx mori*.—Dr. Toshio Ito . . 527

GENETICS

Autogenous Necrosis in an *Antirrhinum* Species Hybrid.—B. J. Harrison 527

Frequency of Quadrivalents in Autotetraploid Plants.—Dr. J. W. Morrison and Dr. T. Rajhathy 528

OCEANOGRAPHY

Southern Atmospheric Cyclones and the Whale Feeding Grounds in the Antarctic.—Dr. C. W. Beklemishev 530

PSYCHOLOGY

Time Uncertainty and Choice Reaction Time.—Paul Bertelson and Jean-Paul Boons . . 531

The Relativity of 'Meaning'.—Dr. W. Ross Ashby 532

CHAPMAN & HALL

Two new books from
JOHN WILEY & SONS, INC.

PHOTOCONDUCTIVITY OF SOLIDS

By RICHARD H. BUBE

This book offers a comprehensive analysis of the photoconductivity of solids and represents an important addition to the literature on the subject. It provides a unified physical description and interpretation of photoconductivity phenomena, drawing examples from many different kinds of materials. In addition, the correlation between photoconductivity and other related phenomena in insulators and semi-conductors is given. *Illustrated. 118s.*

NUTRITIONAL EVALUATION OF FOOD PROCESSING

Edited by R. S. HARRIS and H. von LOESECKE

In this book the known effects of processing upon the nutrient content and nutritional value of foods are evaluated. Wherever possible suggestions are made regarding changes in processing procedures which would minimize losses in nutritional value. Thirty-three experts have contributed to the volume, making it one of the most comprehensive and authoritative studies of the subject ever published. *Illustrated. 96s.*

37 ESSEX STREET, LONDON, W.C.2

PRECISION BS INSTRUMENTS

Spectrometer No. 3

with circle of 30 cm. diameter divided to read by vernier to 10 seconds

PRISM TABLE rotates and is fitted with levelling screws

TELESCOPE AND COLLIMATOR have centring adjustment

EYEPIECE is of 25 mm. separation

Our technical staff are always available to give help or advice on any of our instruments or their uses.

Bellingham & Stanley Ltd.

DEPT. N, 71 HORNSEY RISE, LONDON, N.19

PHONE: ARCHWAY 2270

Sole distributors in U.K. for Schott Monochromatic Interference Filters

EDUCATIONAL CO-OPERATION IN THE COMMONWEALTH

THE Commonwealth Teachers Bill, which received a second reading in the House of Commons on May 17 and the Royal Assent on June 2, gives effect to the second of the undertakings given by the United Kingdom Government at the Commonwealth Education Conference at Oxford last year. Steps have already been taken to give effect to the decisions relating to the Commonwealth Scholarship and Fellowship Plan, arrangements for the administration of which were outlined in a White Paper issued last November, and a Bill establishing the Commonwealth Scholarship Commission to administer the Plan in the United Kingdom was passed by Parliament in December 1959 (see *Nature*, 185, 214, 271, 505; 1960). On that Plan and on schemes for the training of teachers and for promoting recruitment of United Kingdom teachers for service in Commonwealth countries overseas, the Government proposes to spend £6 million during the next five years to fulfil the undertakings assumed at the Conference; of this sum, about £3·75 million will be required for the purposes of the new Act.

These latter schemes are described in a further White Paper on Commonwealth Educational Co-operation issued in May*. While in the long term the training of sufficient teachers to meet normal requirements can be achieved only by the efforts of the countries themselves, the Oxford Conference agreed that, in the short term, help from other Commonwealth countries could be decisive if carefully chosen and directed towards the most influential parts of the educational system of the recipient country. The United Kingdom Government, therefore, undertook to take steps, in co-operation with the responsible authorities, to make available to Commonwealth teachers additional places in teacher-training institutions in Britain and, within the limits of the funds available for the purpose, to provide grants covering fees and full maintenance to Commonwealth teachers nominated by their respective Governments, so as to enable them to take up these places. The sending country will normally bear the cost of travel to and from the training institution and the British Council will act as agent of the Commonwealth Relations Office and the Colonial Office for the payment of students' fees and allowances, and will be responsible for their reception on arrival in the United Kingdom and for their general welfare. They will be placed by a Commonwealth Bursary Unit in consultation with the training institutions. Provision will be made in the estimates of the Commonwealth Relations Office and the Colonial Office for expenditure of about £285,000 a year, and also some financial provision to afford opportunity to members of the staffs of teacher-training institutions in Britain at which such Commonwealth teachers study, to visit parts of the Commonwealth to see something of the environment in which these teachers will work on completing their training.

The Government also agreed at the Oxford Conference to endeavour to increase the number of teachers who take up posts overseas by special encouragement of recruitment for posts in those areas of the Commonwealth where the shortage of teachers is most acute. Steps are already being taken in co-operation with local education authorities and other responsible bodies to improve the arrangements for seconding and re-employing teachers, for safeguarding their promotion prospects and superannuation benefits in the United Kingdom, and for promoting wider recognition both by teachers and their employers of the value of service overseas in the Commonwealth. The Government has also undertaken to provide, at the request of certain Commonwealth countries unable to offer salary and conditions of service to meet the reasonable needs and expenses of expatriate teachers, special financial assistance to United Kingdom teachers volunteering to fill approved key teaching posts overseas. Such posts may be in primary and secondary schools, teacher-training institutions, technical colleges and universities, and, as defined by the Conference, are, broadly speaking, posts which require teachers with qualifications not locally available in sufficient numbers, or posts in which the teachers will be able to play a creative part in the educational progress of the country concerned.

The measures proposed will include payment of special allowances to bring the salary offered by the local employer up to the level which would have been received in the United Kingdom, and to offset higher living costs and local taxation, as well as payment of fares to and from the United Kingdom and other miscellaneous forms of assistance. Arrangements for posts in universities and university colleges will be drawn up on the advice of a sub-committee of the Universities Advisory Committee of the British Council on which, besides the Council, the universities, the Inter-University Council for Higher Education Overseas, the Commonwealth Relations Office and the Colonial Office will be represented. It will not be made a condition of posts attracting these special allowances that Commonwealth authorities should use an officially recognized United Kingdom recruitment agency; but in view of the considerable experience of the British Council in this field, it is hoped that the services of the Council will be widely used. The White Paper estimates that recruitment of teachers under this scheme will increase from about 75 in 1960 by about 20 a year to 135 in 1963 and succeeding years, and that the cost of this programme to be borne on the estimates for the Commonwealth Relations Office and the Colonial Office will

* Commonwealth Relations Office: Colonial Office. Commonwealth Educational Co-operation. Pp. 7. (Cmnd. 1032.) (London: H.M. Stationery Office, 1960.) 6*d*. net.

rise to about £700,000 a year by the end of the five-year period.

Apart from these measures, the White Paper points out that the Government hopes to make available a substantial number of additional places for Commonwealth students in technical colleges in Britain during the next decade, and to expand training facilities for Commonwealth students in British industry. The Government is represented on the Commonwealth Education Liaison Committee, set up, together with the Commonwealth Education Liaison Unit, to improve and further Commonwealth collaboration in education. The United Kingdom is also participating in a meeting, probably early in 1961, of Commonwealth experts in teaching English as a second language to study the problems in this relatively unexplored field. The White Paper confirms the acceptance of the Government of India's invitation to attend the next Commonwealth Education Conference at New Delhi in 1961.

In presenting the Bill, which received a remarkable welcome in both Houses of Parliament, the Minister of State for Commonwealth Relations, Mr. C. J. M. Alport, said that in February the Minister of Education, at a Conference on Teachers for the Commonwealth, had advanced several proposals, including the formation of a national council for the supply of teachers overseas, the preparation of a code of secondment for teachers going overseas, and a code of terms for the appointment of such teachers; and it was hoped that in this way and through the provisions of the Bill it would be possible to provide teachers of the calibre and experience required. Mr. Alport said that the Minister was much encouraged by the response at the Conference to his appeal, and Mr. Alport himself repeated the appeal he had made in the debates on the Commonwealth Scholarships Act to employers and to teachers to consider the value and importance of service overseas both to themselves as individuals and to the countries of the Commonwealth.

Mr. Alport emphasized that the success of the scheme would depend primarily on the willingness of individuals to serve abroad for two or three years; but despite the shortage of teachers in Britain he did not believe the numbers required are beyond our capacity. As regards the provision of training facilities in the United Kingdom, Mr. Alport anticipated that the full number of some 400 Commonwealth bursars would be coming to the United Kingdom in the first year of operation. Dealing with the Bill itself, he explained that its provisions had been so drafted as to include bursars who were not actually British subjects or Commonwealth citizens, and to enable the United Kingdom to provide experts other than those of the teaching profession but whose services in Commonwealth countries could be of great material advantage to their educational system as a whole. He estimated that there are at present about 30,000 Commonwealth students in the United Kingdom, of whom about 12,000 come from independent member countries and 18,000 from dependent territories. Of the total, 7,000 are at universities, about 7,000 at technical colleges and 730 already at teacher-training colleges, for which already there has been demands for 300–400 places.

Afterwards, in a written answer to a question in the House of Commons on May 27, Mr. Alport stated that so far some 350 applications had been received for bursaries under the scheme described in the White Paper. The largest group would be experienced teachers taking a wide range of one-year courses in educational theory and practice. Another large group would be taking courses in technical teacher-training and other specialized subjects, and a third group would be receiving courses of initial teacher-training. It was hoped that the first teachers would go overseas under the second scheme during the latter part of this year and that these teachers would cover a wide range of subjects. The United Kingdom authorities are at present assessing the needs of the overseas Commonwealth countries in the light of the information so far received.

Some misgivings were expressed during the debate, and again on May 23 in committee, when the establishment of an Overseas Education Service was suggested, as to whether, in view of the difficulty so far experienced in persuading teachers already teaching in Britain to go abroad for a time, the scheme is likely to succeed. It was emphasized, however, that the posts in question are key posts and in places where recruitment is particularly difficult. Mr. R. Thompson, the Under-Secretary of State for Commonwealth Relations, replying for the Government, said he thinks it unlikely that the allowances would lead to anomalies or create a privileged group or an aristocracy among teachers: the real safeguard, he said, lies in the eligibility of those returning at the end of a contract for re-employment under the scheme. Nevertheless, it was appreciated that, particularly for senior university teachers, there are real difficulties to be overcome in regard to promotion prospects, and much will obviously depend on the interest taken in the scheme by the universities and the reality of their support in such matters.

One point raised in the debate, by Dr. Alan Thompson, concerned the participation of the Union of South Africa. As Dr. Thompson remarked, the educational system of South Africa seems to be in conflict with some of the objectives of the White Paper. Nevertheless, as was pointed out by Mr. I. F. A. de Villiers in *Nature* of March 26, p. 893, South Africa proposes to take part in both the Commonwealth Scholarship Plan and the Commonwealth Education Liaison Committee. This was later confirmed in the House of Commons (*Nature*, July 9, p. 113). Clearly, difficulties must arise, not simply because of the way in which apartheid is practised and the educational principles of the Act are violated in South Africa, but also quite as much through the rejection by the Union Government of the idea of university autonomy. As Sir David Eccles emphasized, this is partly a matter of creating an appropriate climate of opinion, not only to ensure that those who

teach overseas suffer no professional handicap on their return, but also to help teachers who are seeking information before they go abroad and to keep local education authorities and the universities continually aware of what is going on and the various needs. In this connexion, Sir David indicated that something like ten visits abroad a year from members of the staffs of training colleges to enable them to familiarize themselves with the local conditions and needs of the teachers they are training in Britain are planned.

Little was added to all this in the debate in the House of Lords on May 30. In moving the second reading, the Earl of Home expressed the Government's appreciation of the co-operation which had been shown by the teachers' representatives, by the local authorities, by the churches, and by the teacher-training institutions, which had pledged themselves to make this scheme work. They had devised a draft scheme of secondment to which the Government hoped all the education authorities would subscribe and which it hoped they would all adopt. Lord Home also said that Dr. V. S. Jha, lately vice-chancellor of Banares Hindu University, would be the first director of the Commonwealth Liaison Unit. In both Houses of Parliament there was thus evidence of the imaginative response and enthusiasm for which Lord Home appealed at the time of the Conference last year, and that in Parliament at least it is fully realized that assistance in educational development is one of the most important forms in which technical aid can be given to the under-developed countries, within and without the Commonwealth.

That this is not more generally recognized is unfortunately only too true, as the reluctance of the Federal Government to take over the Copperbelt Technical Foundation set up three years ago by the Anglo-American Corporation and the Rhodesian Selection Trust shows. The second of these two mining groups was concerned with the great need to train Africans for more responsible work, but when the Technical Foundation was launched it admitted, and still admits, Europeans only. When, during the copper slump, the Government of Northern Rhodesia was approached for a grant, it made such a grant contingent on the Foundation becoming multi-racial and admitting Africans, as the Rhodesian Selection Trust had desired from the start. The Federal Government made such a grant, however, without any conditions but did not desire to take over the running of the institution. The Government of Northern Rhodesia is debarred, however, from taking over the Foundation as it stands, because European education is a Federal responsibility; but it could, and is willing to, do so if the Foundation is thrown open to suitably qualified youths on merit and regardless of colour, since African education, including apprenticeship and the type of instruction given at this institution, is a territorial responsibility.

Meanwhile, the importance of trained man-power generally and of technical education in particular in like territories is emphasized from one source after another—by Mr. Kenneth Younger in his Sydney Ball Lecture at Oxford last November, and in a subsequent book, by Dr. B. V. Bowden, in articles on the universities' task in Ghana and on technical education there, based on his recent visit, and in the latest report from the Colonial Development Corporation. Dr. Bowden believes, indeed, that if there were an adequate supply of technologists, Ghana need not look elsewhere for most of its professional administrators. He anticipates that if its universities in the next few years can educate the scientists and technologists who are needed in ever-increasing numbers as the country takes its place in modern society, a vital intellectual stimulus would be provided to both staff and students, apart from the benefit of its impact on industry, agriculture and public health; but an essential part of that programme is an active programme of research, especially in agriculture, medicine and engineering, into the formidable technological programmes which confront the country to-day.

In fact, however, Dr. Bowden regards technical education in Ghana as essentially a pyramid without a base, because there is no adequate provision for the education of the craftsmen, charge-hands, foremen, under-managers, etc., whom the graduate engineers, for whom educational facilities are provided, will need. If Ghana is not to use most of its graduates as technicians and clerks, he believes that country will need to spend very much more on non-university education than it does on the universities, and it may well be that in this field of technical education the help which could be forthcoming through the schemes outlined in the White Paper on Commonwealth Educational Co-operation may be most valuable and most needed. Dr. Bowden refers, moreover, to the need for more opportunities for engineering graduates in Ghana to gain practical experience; and it would seem that his suggestion that the Government of Ghana should arrange for its graduates to go abroad to join one of the great firms that have organized postgraduate apprenticeships for many years is at least possible, under the further measures contemplated in the final paragraph of the White Paper.

THE GALATHEA EXPEDITION

Galathea Report

Scientific Results of the Danish Deep-Sea Expedition round the World, 1950–52. Edited by Dr. Anton F. Bruun, Captain Sv. Greve and Prof. R. Spärck. Vol. 1: Pp. 260+8 plates. 90 D.kr. Vol. 2: Pp. 253+4 plates. 75 D.kr. Vol. 3: Pp. 87+85 plates. 60 D.kr. (Copenhagen: Galathea Committee, 1956–1959.)

WHEN the Galathea Expedition was planned, the deepest parts of the ocean floor had yet to be explored. Accordingly, the main aim was to sample the benthic fauna, if indeed this existed, at levels beyond 6,000 m. Such deep regions, in the form of trenches, are found principally in the Indonesian area and in the Western Pacific Ocean.

These three volumes and the narrative published in 1956[1] contain ample evidence that this exacting task was accomplished with conspicuous success. This work (and that carried out by the Russians since 1949) has shown that the deep-sea trenches contain limited but distinct communities of invertebrates. Dr. Anton Bruun, the leader of the Galathea Expedition, refers to such animals as the hadal fauna[2]. The recent dive of the U.S. Navy Bathyscaphe *Trieste* in the Challenger Deep (Marianas Trench) has now revealed that fishes may also range into the hadal regions.

Most of the papers in these reports deal with groups of benthic invertebrates taken at depths beyond 6,000 m. (Volume 1 : Actiniaria (Carlgren) ; hydroids (Kramp) ; Echinoidea, Asteroidea and Ophiuroidea (Madsen) ; Holothuroidea (Hansen) ; Crinoidea (Gislén) ; Polychaeta (Kirkegaard) ; Isopoda and Tanaidacea (Wolff).) Volume 1 also contains a full report on the deep-sea Ascidiacea (Millar) and papers on two bathypelagic groups (Vampyromorpha (Pickford) and whale-fishes (Rofen)). A complete account of the Pycnogonida (Fage) will be found in Volume 2, which also contains papers on free-living nematodes (Wieser) and on certain new species.

Considering only the papers concerned with animals from the hadal zone, nearly half the species (40 out of 87) have proved to be new. This certainly suggests that the deep-sea trenches contain a special fauna, although certain contributors point out that this idea may need to be qualified when the abyssal regions of the deep-sea floor (2,000–6,000 m.) have been more thoroughly explored. The trophic structure of the hadal fauna also seems to be distinctive. It appears from these and Russian reports that predatory animals such as the asteroid and ophiuroid echinoderms and the decapod crustaceans are scarce or absent in extreme oceanic depths. The greater part of the benthic biomass generally consists of the ooze-eating holothuroid echinoderms. Where conditions favour higher rates of sedimentation, the particle-ingesting pogonophorans may be very abundant.

The station list in Volume 1 will reveal that the expedition devoted much time to trawling and dredging in the Philippine Trench. But before this could be attempted, the trench was thoroughly surveyed by echo-soundings, and an account of this work is given by Kiilerich. Volume 1 also contains the results of two other important aspects of the expedition's programme, the measurement of oceanic productivity (Steemann Nielsen and Jensen) and the study of deep-sea bacteria (ZoBell and Morita).

The radioactive carbon technique now widely used for measuring marine plant productivity was developed just in time for the expedition. A full account of the method and measurements, which were made in all three oceans, is given, and the report ends with a comprehensive and valuable survey of the physical and biological background to oceanic productivity.

Deep-sea bacteria obtained from sediments in the trenches were found to look very like common soil forms, but were shown to grow preferentially or exclusively at the pressure and temperature of their environment. ZoBell and Morita calculate that the carbon content of the standing crop of bacteria in a square metre of sediment (1 centimetre in thickness) is about 2 milligrams. Since marine bacteria are able to oxidize most kinds of organic matter, the authors suggest that these organisms may well be an important food source for mud-eating and filter-feeding invertebrates. But they also remark that nothing is known of the productivity of deep sea bacteria.

Zoologists and palæontologists will welcome the superbly illustrated, detailed account of the anatomy of *Neopilina galatheae* by Lemche and Wingstrand, which takes up most of the third volume. The authors clearly show that this mollusc belongs to the class Monoplacophora, order Tryblidiacea, a group represented at the time of writing by two species, but otherwise known only as fossils in Cambrian, Silurian and Devonian deposits. The metameric repetition of organs, which is most marked beyond the third pedal retractor nerve, is well demonstrated. The systematic and phylogenetic implications of these and other findings are to be considered in a later report.

The last paper in Volume 3 is a short but interesting study by Munk of the pair of plate-like head organs in the abyssal myctophoid fish, *Ipnops murrayi*. The cellular make-up of these structures plainly shows them to be modified eyes, a most curious transformation, but one that may not be confined to the genus *Ipnops*. There is evidence that some parallel may be found in the eyes of the bathypelagic whale-fish, *Ditropichthys storeri*[3]. Closer investigation of this species would now be of great interest.

To conclude, these handsomely produced reports are striking proof of what has been accomplished in oceanic biology during the past ten years. But they are also bound to be a measure of what remains to be done. The thorough, large-scale investigation of the ocean that is now required is beyond the resources of any single nation. It is to be hoped that international effort, such as that being contemplated for the Indian Ocean, will meet this need.

N. B. Marshall

[1] Bruun, A. F., *et al.*, The Galathea Deep Sea Expedition, 1950-52. Pp. 296. (London: Allen and Unwin, 1956).
[2] Bruun, A. F., *Nature*, **177**, 1105 (1956).
[3] Harry, R. R., *Zoologica*, **37** (1), 55 (1952).

STABILITY AND CONTROL OF FLIGHT

Dynamics of Flight

Stability and Control. By Prof. Bernard Etkin. Wiley Books in Space Technology. Pp. xiv+519. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 120*s*. net.

THIS is a modern treatment of the fundamental theory of the stability and control of aircraft. Performance and flutter issues have been specifically excluded. Numerical examples are used to illustrate applications and typical results.

The reader is assumed to be familiar with basic mechanics, aerodynamics and with complex numbers and differential equations. An appendix gives a résumé of vector analysis. On this basis the static stability of an aircraft in its equilibrium states is first analysed and the influence on the stability of various controls, etc., is discussed. The general equations of unsteady motion are then developed in a systematic way. The author starts with the aircraft as a single rigid body and then elaborates on the equations so obtained by adding in turn the effects introduced by the presence of spinning rotors, the control surface movements and finally the effects of elasticity in the system. An attractive feature of the presentation is the fact that from time to time the reader is reminded

of the assumptions behind the various sets of equations by having these collected and listed for him.

Each of the stability derivatives contained in the general equations of motion is discussed next. Formulæ for their evaluation are given or, where this is not possible, the qualitative dependence of the derivative on the perturbation quantity is described. Three appendixes give about sixty pages of formulæ, tables and graphs relevant to stability derivatives, the standard atmosphere, mean aerodynamic chord and centre, etc. The data quoted are taken mainly from the National Advisory Committee for Aeronautics Reports and Royal Aeronautical Society Data Sheets. The National Advisory Committee for Aeronautics notation of stability derivative is used throughout the book. The author directs attention to certain differences in definitions used in Great Britain and the United States.

In successive chapters the stability of small perturbations in the longitudinal and the lateral motions is analysed using the differential form of the equations of motion. Since the subject-matter of the remainder of the book can only be treated fully by the use of mathematical techniques based on Laplace transforms, frequency responses and random functions, a chapter is devoted to an explanation of these techniques. The Laplace transform and frequency response-approach is then used to study the response of the aircraft to actuation of its control surfaces.

The next topic to be treated is that of flight in turbulent air, and here the approach is centred on analysis in terms of the power spectrum of the turbulence.

On the assumption that the aircraft motion is known, there may be occasion to determine (*a*) the input action, given the aircraft parameters, or (*b*) the aircraft parameters given the input action. A chapter is devoted to such inverse problems. This is a topic of considerable practical interest and the value of the short outline given would have been greater had some notes been included on some of the practical difficulties involved.

The last three chapters give the reader an outline of up-to-date applications and techniques by discussing in turn, automatic stability and control by means of feed-back devices, specialization to missiles, and finally the fundamentals of machine computation and simulation. These chapters are brief but nevertheless valuable introductions to very large subjects. This is a carefully prepared and well-presented book which covers a very wide field in a very competent manner.

REFERENCE BOOK OF THEORETICAL PHYSICS

Manual of Mathematical Physics

By Paul I. Richards. Pp. xi+486. (London and New York: Pergamon Press, 1959.) 110*s*. net.

THE author states in his preface: "The goal of this book is to condense established theoretical physics, its applications and its mathematical equipment into a single reference volume of reasonable size without sacrificing either logical continuity or fundamentals".

This seems to be a hopeless attempt. The book has, however, a distinguished German predecessor. "Die mathematischen Hilfsmittel des Physikers", by E. Madelung, is a collection of formulæ and theorems concerning a wide field of advanced topics in theoretical physics which for four decades has been of invaluable assistance to research workers. The influence of Madelung's work on the present book is obvious and beneficial, but emphasis is now shifted to some extent from formulæ to verbal argument.

A 'physics' section covers classical mechanics, electrodynamics and optics; thermodynamics and statistical physics; relativity and the quantum theory of matter and radiation. Both the general principles of the theories and their applications to special problems are taken into account. In addition a number of recent branches of theories are included, and circuit theory and other subjects of technological importance are added. A 'mathematics' section deals with the calculus, complex functions, series expansions and differential equations; integral equations and Hilbert spaces; modern algebra, vectors and tensors; numerical methods, probability and linear programming, to name the most important headings.

It need scarcely be said that the accommodation of this vast amount of material is possible only by very concise wording. This obviously renders the volume unintelligible to all but fairly expert readers. The value of the book should accordingly be assessed by its possible use to competent research workers.

This use is unfortunately somewhat limited because the presentation of the subject does not conform with the author's claim in the preface. The 'physics' section does not show much logical continuity; rather it would appear to be an assemblage of unconnected and incomplete statements. The shortage of space does not prevent the author from indulging in unnecessary verbosity whereby significant points in explanations are lost.

The 'mathematics' section is on the whole better presented, but is burdened by numerous formulæ the origins, applicability and significance of which are not given. 1,200 words are used for the subsection 'signal flow diagrams', which appears to be a method for solving simultaneous equations. I was unable to derive from the text any instruction for operating by this method; nor is there any result shown from which the principles of this method could be inferred. Contour integration is dealt with in 100 words, no result or example being presented. The Lebesgue integral is discussed in 250 words—which should be sufficient for a book of this kind—but no definition of that concept is included. There is an adequate table of Laplace transforms, but no corresponding table of Fourier transforms. These examples may show that also the 'mathematics' section is of limited use only.

So far as the verbal text is concerned the book is scarcely any better than a list of technical terms of theoretical physics and applied mathematics. This shortcoming is all the more surprising as the author repeatedly shows that he has mastered the subject and would be capable of saying much in few words. Presumably he believes that his source book is of interest to some class of readers, whoever they may be.

If the book is regarded as a collection of formulæ it may still be useful to research workers. They may save appreciable time and effort if a formula can be found in the present volume and need not be searched for in some treatise.

R. EISENSCHITZ

EVOLUTIONARY DIVERGENCE

Evolution above the Species Level

By Prof. Bernhard Rensch. Pp. xvii+419. (London: Methuen and Co., Ltd., 1959.) 63*s*. net.

THE distinguished author of this book has long been known for his extensive studies on the island distribution of birds and other vertebrates, and of land snails. This work was done especially in the Malay Archipelago, on which he wrote a valuable treatise in 1936 (which for some reason he has omitted from the bibliography). It led him to take a profound interest in the formation of races and species, and their evolution. The word 'Rassenkreis' was coined by him. His monograph in 1929 on "Das Prinzip geographischer Rassenkreise und das Problem der Artbilding" is a classic. Later on he became engrossed with wider questions about the natural processes of evolution, not only in races and species, but also in the divergence and segregation, if that is the right word, of higher taxonomic groups.

The German edition of "Evolution above the Species Level" was published in 1947, but enhanced in a later version in 1954, of which this English edition is essentially a direct translation by Dr. Altevogt. It is a very solid book, crammed with argument and cited evidence, and well illustrated with text drawings. Though its style is certainly pretty heavy and liberally laced with ponderous terms like kladogenesis, archallaxis, bradytely and hylopsychic, the argument is clearly and powerfully developed. The central idea that the author seeks to prove is that the higher grades of phylogenetic branching can be explained by the same orthodox beliefs about natural selection as can race formation and speciation. This involves him naturally in an all-out attack on such directional theories as orthogenesis, which he takes considerable trouble to demolish.

Prof. Rensch has an enormous acquaintance with the literature on evolution, including many aspects of comparative anatomy and development, and he uses many different sectors of zoology as channels of argument, which are gradually united to try to prove the central theme. Although the general integrity of this sifting and assembling process is obviously high, there is a tendency to accept other people's facts and conclusions at their face value, instead of critically testing their authenticity. I was, for example, startled at being quoted in support of the view that there is no natural population balance in animal communities. The reader may perhaps feel as if he were walking through a very well-arranged museum, in which the tickets on each exhibit instruct him clearly what to believe. But the theories are put forward logically, and on the whole cogently. If one believes mutation and natural selection to be the sole basis of race and species formation, the rest of the argument follows fairly convincingly. But one should remain at liberty to wonder if the first assumption contains the whole truth about evolution. The evidence against such ideas as orthogenesis is powerfully marshalled and convincing, though it could partly stand alone on its own merits.

Two special chapters may be mentioned that are interesting, but slightly out of the main stream of argument: one on the absolute rate of evolution in producing taxonomic groups of different levels (that is to say, species, family, order), and another about the evolution of higher psychic processes. But the main message is continually hammered at us: "The evolution of new structural types and of new organs needs no other explanation than specific and generic differentiation, i.e. the combined effect of mutation and selection". The book is beautifully printed, and there is a vast and useful bibliography.

C. S. Elton

THE TWO HEREDITIES

The Future of Man

By Prof. P. B. Medawar. (The B.B.C. Reith Lectures, 1959.) Pp. 128. (London: Methuen and Co., Ltd., 1960.) 10*s*. 6*d*. net.

GOOD lectures when published often make poor reading. The 1959 Reith Lectures make good reading, though as lectures the author views them unfavourably: "they were too closely reasoned", he writes, "and often made unfair demands on the listener's attention". The conciseness of expression and the balance of phrases in neat antithesis, qualities which make listening difficult, are a virtue in print and in scientific writing a rare merit. Explaining the concept of 'fitness', for example, he writes: "All the people alive 100 years from now will be our descendants, but not all of us will be their ancestors". The reader can pause and look again—and often will in reading this text: the spoken sentence is past before the listener is aware that something important has been said.

The approach in the earlier lectures may have discouraged some of the less-sophisticated among his audience. "I decided that these lectures were to be about the process of foretelling (the future of man) rather than about what is actually foretold." In each of various aspects of forecasting human development, Prof. Medawar shows the complexity of the mechanisms involved. For example, on the relation between intelligence and fertility his lecture opens with five possible explanations of this relation and proceeds to show that the inference of a decline in national intelligence is equally complicated by difficulties. But this kind of discipline in thinking about the implications of the past half-century of research in human biology is precisely what is most needed. Since so few biologists have been willing to discuss their subject on this scale and in this strict way, the field has been left to the naïve thinkers and the propagandists to proclaim that medical science is preserving an unfit population, that birth control is bound to have evil consequences, that the laws of genetics have an over-riding authority. The positive contribution of these lectures is in their demonstration of the muddled thinking of the upholders of the doctrine of 'geneticism'—"the idea that man's genetic constitution is not merely important but all-important".

Do genetical laws set predictable limits to man's future development? This is the central theme of the lectures, and Prof. Medawar's position is in sharp contrast to that of the older social biology. The answer, introduced in the final pages, is that man has two systems of heredity, one genetical, one cultural: the interaction of these two systems changes the prospect entirely. This is really the beginning, not the end, of the topic of the future of man; but it takes the topic beyond biology into the social sciences.

The bringing together of these two systems of heredity suggests a comparison with another widely discussed lecture of 1959, the Rede Lecture, which

showed the need for merging our two cultures, the scientific and the literary. Of recent years, the non-scientific world seems to be assimilating quite successfully the simpler concepts of physics, but is still far behind in its grasp of the trends in the biological sciences. These Reith Lectures provide an example of the kind of thinking and talking that must be done if the more recent developments of biology and genetics are to win their proper place in the general education and the intellectual culture of our population.

J. D. NISBET

BIOCHEMISTRY AND HEREDITY

The Chemistry of Heredity

By Prof. Stephen Zamenhof. (Publication No. 365, American Lecture series. A Monograph on American Lectures in Living Chemistry.) Pp. xi+106. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas, 1959.) 34*s*. net.

THE great and diversified scientific effort which we are witnessing to-day all over the world has brought with it problems of communication. The expanding list of scientific journals bears witness to the volume of publications by which scientists are attempting to inform others of their discoveries. Such publications, however, may appeal only to like-minded specialists. Nevertheless, scientists of all disciplines as well as medical practitioners do, from time to time, feel the need to acquaint themselves with the state of knowledge in a particular field. Another, much larger, group of potential readers interested in the facts of scientific advance is the general public. Many of its members have helped to finance "the enlightened programs of research grants in our country" to which Prof. Zamenhof so rightly pays tribute in the dedication of his book. In the choice and presentation of the material of this monograph the author has apparently tried to aim at the professing scientists, the medical readers as well as the curious but unqualified.

In the introduction the author prepares the ground for the subsequent discussion of the possible mechanisms for the transmission of heredity by chemical compounds. Prof. Zamenhof then lists in outline required properties of heredity determinants and gives examples of classes of biological systems which must reasonably be under their genetic control. In the second chapter evidence is given for the central thesis of this book that heredity determinants are chemical substances. The non-specialist or even student is gently led towards the objective that deoxyribonucleic acid is the most plausible carrier of heredity. Due weight is here given to the direct proof for this postulate where viruses are concerned, which Prof. Zamenhof puts beside the almost incontrovertible but indirect evidence for the genetic role of deoxyribonucleic acid in higher organisms. A résumé of the structure of the nucleic acids is then followed by a discussion of the implications of those biochemical experiments by which nucleic acids have been synthesized *in vitro*. Under the heading "Mutation" the author regrettably only touches on hypotheses and on the genetic concept of carcinogenesis. Perhaps he wished to keep the account of work so close to his own promising field short for the sake of clarity. The facts of cytoplasmic inheritance are authoritatively stated and the subject well set within the context of the book. The remainder of this monograph is concerned with research in biochemical genetics: studies with micro-organisms and the examination of hereditary defects in man. The reader is given a hint of the problems, theoretical and practical, which confront investigators in this field.

This is a book that can be recommended to scientists and medical men who wish to widen their horizons, and to students providing they can persuade their library to buy it. The problem of how to present scientific facts, let alone the complexities of the chemistry of heredity, to the lay reader has not been brought closer to a solution by this volume.

The book is well produced; misprints are practically absent, but the text gives examples of bizarre notions of how to divide words. The comprehensive bibliography should be useful to all readers alike.

P. COHN

RECENT AMERICAN RESEARCH IN NEUROPSYCHIATRY

Chemical and Molecular Basis of Nerve Activity

By David Nachmansohn. Pp. xi+235. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 7.50 dollars.

International Review of Neurobiology

Vol. 1. Edited by Carl C. Pfeiffer and John R. Smythies. Pp. xii+383. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 10 dollars.

Neuropharmacology

Transactions of the Fourth Conference, September 25, 26 and 27, 1957, Princeton, N.J. Edited by Harold A. Abramson. Pp. 285. (New York: Josiah Macy, Jr. Foundation, 1959.) 5 dollars.

THESE three books cover recent American researches on various aspects of the nervous system. The emphasis is on the nature of transmission, the chemical isolation of naturally occurring substances believed to have physiological or pathological importance, and the effects of drugs. In each case, the publishers are to be congratulated on having produced a handsome volume, well illustrated and carefully indexed. The bibliographies are satisfactory. With some qualifications, it may also be said that the authors, too, have given us something of which they may be proud.

Nachmansohn's book is the only monograph. It represents the results of nearly a quarter of a century's work by the author and colleagues on the metabolism of acetylcholine and its associated enzymes. It is a well-written, interesting, and coherent account of the progress which has been achieved. Beginning with a discussion of the physical events during nerve-activity, the author successively deals with a hypothesis of chemical transmission, the high speeds at which hydrolysis can take place, and substances which are capable of inhibiting the enzymes of this system. He goes on to describe the physicochemical exchanges in the electric organs of certain fish, and then makes a bold attempt to define in detail the role of acetylcholine in conduction. Here, there is a useful diagram to explain the author's views. The way in which nerve-gases, insecticides, and antidotes may be fitted into this scheme is next discussed. The book closes with chapters on the complex nature of the changes in the permeability of conducting membranes

and on the problems of synaptic transmission. In his concluding remarks, the author freely admits that we are only beginning to understand the "chemical forces and structural arrangements" of these membranes.

The editors of "The International Review of Neurobiology" write in their preface that their aim is to enable workers in many different, but related, fields to keep abreast of recent advances. This book is composed of eight articles, each by different authors. The first two are mainly electro-physiological. The third and fourth are neurochemical. The fifth is on the psychophysiology of vision, with particular reference to the effects of various stresses (for example, anoxia and induced hypoglycæmia) and of a number of drugs. The last three articles are concerned with metabolic studies in disease.

As is almost inevitable with such a conglomeration of contributors, the merits of the articles vary a good deal. Particularly interesting were W. R. Adey on the rhinencephalon and epilepsy, Catherine Hebb on chemical agents of the nervous system, and Carl C. Pfeiffer on parasympathetic humors. The least impressive were the last three articles, which attempt to relate products of abnormal metabolism to schizophrenia and even multiple sclerosis.

The volume entitled "Neuropharmacology" has the weighty disadvantage that it is an account, in the form of a dialogue, of a conference which was held more than two years before the book was published. For the reader to-day, it thus cannot altogether avoid the air of staleness which clings to an old newspaper discovered by chance in an attic. Such a document may, and often does, carry an absorbing transitory interest for him who vividly recalls the events described; yet may altogether fail to hold the attention of those who have not any reason to remember. In addition, dialogue is a challenging form of literary endeavour. Perhaps even Plato's genius does not always avoid stultifying thought by irritating changes of direction, as the argument is developed. A mode of human communication which is inevitable, and indeed proper, in a conference room too easily becomes irksome if it is inscribed in print.

Dr. Fremont-Smith, in explaining the scope of the book, makes a convincing plea for the usefulness of the conference which is reported; but admits that the form of the publication has already given rise to criticism and that a few critics have stated that they would have preferred a "depersonalised summary". If, by some device, the opening speakers had been allowed in this volume to complete their themes unobstructed, as, after all, usually happens in conferences, there would have been less reason to object to a subsequent discussion. In this presentation, we are not even allowed a summary of the opener's remarks.

Four subjects are discussed: (1) "The Effect of Respiratory Poisons and Anoxia on Siamese Fighting Fish in Relation to LSD–25 Reaction" (Dr. Abramson); (2) "Clinical Studies with Taraxein" (Dr. Heath); (3) "'Stop' and 'Start' Systems" (Dr. Lilly); (4) "Some Relations between Chemical Structure and Physiologic Action of Mescaline and Related Compounds" (Dr. Alles).

Dr. Abramson's article includes piscine illustrations which are intriguing, but his interlocutors are allowed to get at him too soon. Towards the end of his second page (p. 13), the dialogue runs as follows:

"*Abramson*. I might add here that we have data on what the 1-methyl and what the 1-acetyl derivatives of *LSD*–25 do to man.

Marrazzi. You must have had a reason for not using the standard presentation of the log of the dose, which would straighten out the curve.

Abramson. I prefer to deal with the actual data rather than a log.

Hoagland. Are they log relationships or semilog plots?"

Thereafter, Dr. Abramson gets hounded, so to speak, from log to log or from plot to plot for several pages, before he or the scientific dogs who pursue him return to the absorbing human trail.

Dr. Heath fails to impress with taraxein. It is clear from the voices of the hounds after him that they fully realize that the scent which he is laying is not absolutely reliable.

Dr. Lilly's 'stop' and 'start' systems are of great interest. Electrodes accurately and permanently implanted into the brains of monkeys enable him to define certain areas, the stimulation of which gives rise to characteristic behaviour. Moreover, the dogs of dialogue let him run longer distances before bringing him to bay.

Dr. Alles gets the fairest start of all, and is extremely informative on the structure and action of phenylethylamines for 20 or 30 pages, before the pack catch up with him and pull him down. Thereafter, the run of the argument deteriorates, until he escapes with a second wind for five or six pages towards the end.

This book would have much to be said for it, were it not for its regrettable art-form. D. H. Brinton

ADVANCES IN VETERINARY SCIENCE

Advances in Veterinary Science
Vol. 5. Edited by C. A. Brandly and E. L. Jungherr. Pp. xi+450. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 14 dollars.

THE fifth volume of "Advances in Veterinary Science" embraces seven chapters of varying interest to veterinary surgeons in Great Britain and Overseas.

The first chapter, dealing with the examination of the eye and eye operations in animals, breaks new ground as well as consolidating knowledge gathered from a wide range of experience. Surgeons, especially those interested in small-animal surgery, will find in this chapter a wealth of valuable information. In the second chapter, '*Q*' fever is dealt with in all its aspects and, being a relatively 'new' disease, will be studied with more than topical interest by both medical and veterinary workers interested in public health.

Rabies forms the subject of the third chapter. While it might have been thought that everything about this, one of the oldest diseases known to mankind, was already understood, readers will find in this chapter much new information on the diagnosis and control of the disease. New human rabies vaccines of duck-embryo and chicken-embryo origin are discussed and their promise in general use assessed. Of special interest to workers in Africa are the chapters on eradication of the tsetse fly from Zululand and that on theilerioses.

To those working in the North American continent the subject of infectious bovine rhinotracheitis,

which is dealt with in the sixth chapter, will be of special interest. The virology of this disease is dealt with at some length, and the interesting and fundamental observations that viruses are able to mutate and modify their tissue affinity and host specificity will no doubt be welcomed by many workers in this field. The last chapter deals with tissue culture in veterinary medical research, and in the discussion on this chapter a number of vital questions are posed, prominent among them being the question of the simultaneous vaccination of cattle against a number of viral diseases and the possibie interference between viral agents in a mixed vaccine.

The subjects embraced in this volume do not lend themselves to profuse illustration except that covered by the first chapter, in which a number of excellent photographs and diagrams are supplied. The references and indexes are, as in the previous volumes, most comprehensive and leave nothing to be desired. This fifth volume is a worthy companion to its predecessors and will further enhance both the academic and practical value of the series.

H. Burrow

FLORA OF THE ZAMBESI BASIN

Flora Zambesiaca

Mozambique, Federation of Rhodesia and Nyasaland, Bechuanaland Protectorate, Vol. 1, Part 1. Edited by A. W. Exell and H. Wild. Pp. 336. (London : Crown Agents for Oversea Governments and Administrations, 1960. Published on behalf of the Governments of Portugal, The Federation of Rhodesia and Nyasaland, and the United Kingdom.) 25*s*.

THE publication of the first part of the "Flora Zambesiaca" is the first fruit of many years of co-operation between botanists and administrators of several botanical institutions and almost as many governments ; the second part is already in the press and should appear later this year.

The area covered includes the vast territories of Africa to the south of the former Congo Belge and Tanganyika, to the east of Angola and South West Africa, and north of the Union of South Africa, and, as is claimed in the introduction, the aim of uniformity of treatment within certain limits of freedom has been admirably attained. This in itself is a remarkable testimony to the practical uniformity of taxonomic methodology. In no family or genus treated in this first part is there any evidence of mere specimen—as distinct from species—description, but at the same time all the contributors have taken care to avoid inclusion of discontinuous variables in the same taxon.

During the preparation of the work, all contributors have published necessary notes, nomenclatural and taxonomic, in a series of papers in the *Boletim da Sociedade Broteriana* ; there are only four 'new' names in the Flora. The introduction is printed in English and Portuguese and the glossary, adapted from that of the "Flora of West Tropical Africa", although arranged according to the English entries, includes also the Portuguese equivalents. The key to families has been produced by J. E. Dandy following the pattern of, and adapted from, Hutchinson's "Families of Flowering Plants". The second edition of the latter was not available when the key was prepared. The key occupies twenty-four pages, and Portuguese readers may think that a version in their language might be an improvement, though it is understood that the English key has been reprinted and has found a ready market among them.

The general text follows the well-tried system of Bentham and Hooker, with some modifications. The gymnosperms, by J. Lewis, with two genera and six species of cycads, two species of *Podocarpus* and one each of *Widdringtonia* and *Juniperus*, presented no great taxonomic difficulty, but a uniformity of treatment with that of Melville in the "Flora of Tropical East Africa" is readily discernible. The two texts were prepared independently, one at the British Museum and one at Kew. The treatment of the Ranunculaceae by Exell and Milne-Redhead is essentially the same as that of the earlier flora, some of the errors of the latter being now corrected. Dr. Robson is to be congratulated on his bold treatment of the difficult family Annonaceae. There is no evidence that his new synonymy is too extensive ; it is a clear testimony to his painstaking examination of all relevant available literature and specimens with a view to determination of real specific limits and intraspecific variation. The same author is also responsible for the family Violaceae. The Menispermaceae, by Dr. G. Troupin, follow the same general pattern as the same author's treatment of the family in the "Flora of the Belgian Congo", but he has not been afraid to introduce improvements and corrections wherever these have become necessary.

Of the other larger families included in the present part of this Flora one might mention Capparidaceae and Flacourtiaceae by Dr. Wild, and Cruciferae and Polygalaceae by Mr. Exell. Other contributors are Dr. F. A. Mendonça (Nymphaeaceae), Mr. P. Taylor (Resedaceae) and Dr. G. Cufodontis (Pittosporaceae).

Several artists have contributed to the 58 plates of very fine line drawings illustrating no fewer than 80 genera. (It should be noted that the figure and text concerning *Cladostemon kirkii* are erroneous. The fruit of this species is some 22 cm. in diameter.) Most of these have been prepared specially for the Flora by Miss L. M. Ripley and Miss G. W. Dalby ; some have been reproduced from Hooker's "Icones Plantarum" by permission of the Bentham-Moxon Trustees ; some are reproduced from the "Flora of Tropical East Africa". All of them are well chosen, beautifully executed and printed and should help considerably in generic identification. The coloured frontispiece depicting *Cleome diandra* Burch. is a most satisfying picture ; it was adapted from a field water-colour sketch made by the late Mrs. E. J. Lugard (not "H. E." as in the legend) when she accompanied her husband on his expedition to Ngamiland in 1898.

One could wish that Mr. Exell's account (pp. 23–34) of the history of botanical exploration in the area had been much more extensive. Although detailed itineraries such as that given for Sir John Kirk by Miss Hayes (pp. 35–37) may be unnecessary, more details concerning other collectors would have been of considerable interest and permanent value. One feels that undue attention has been given to limiting the size of this part, without due regard to the possible value of recording much of the bibliographical and biographical research which the contributors must have carried out. In view of the fact that the complete Flora will run to some thousands of pages, the editors might well have used more than a mere 78 pages for introductory matter which includes title-page, preface, glossary and key to families, as well as a brief selected bibliography and list of abbreviations. An opposite policy has been

followed by the editors of "Flora Malesiana", in which some hundreds of pages have been devoted to introductory matter in each of the two volumes so far published. It is understood, however, that Mr. Exell proposes to rectify this in a separate work.

The lay-out of the general text is a compromise between completeness and utility. The descriptions of families, genera and species have been pruned to essentials, with emphasis on characters that are regarded as diagnostic for each category. References to the literature are also pruned to avoid mere repetitions; in the case of genera only the original place of publication is given, though many readers might have been pleased to have also a reference to a recommended later work. No reference at all is given for families. Specimen citation also is limited to a single specimen from each of the large areas marked on the folded map provided in a cover pocket, and this is followed by a brief indication of total distribution and habitat.

Dichotomous keys to genera and to species need to be tested over a long period before their true value can be assessed, but it is usually possible to estimate their workability by inspection. In this Flora considerable pains have been taken to use absolute contrasting characters; mere size differences have been used but rarely. Such treatment inspires a confidence which in the tests I have made has been shown to be well founded.

The text and illustrations have been carefully edited, and typographical errors are few and unimportant; even on p. 332, where the two lines appearing at the top of the page have jumped from the bottom, no inconvenience will be caused. The book is dedicated to the memory of the pioneer collectors in the area, Loureiro, Baines and Kirk. Everyone concerned is to be congratulated on the production of a really useful modern Flora. A. A. Bullock

CELLS AND THEIR ENVIRONMENT

Cell, Organism and Milieu

Edited by Prof. Dorothea Rudnick. (Seventeenth Symposium on the Society for the Study of Development and Growth.) Pp. v+326. (New York: The Ronald Press Company, 1959.) 8 dollars.

The Relationship between Nucleus and Cytoplasm

Proceedings of the Symposium held June 9–13, 1958, at l'Université Libre de Bruxelles, Belgium. Edited by Dr. R. J. C. Harris. (*Experimental Cell Research*, Supplement 6.) Pp. viii+276. (New York: Academic Press, Inc., 1959.) Cloth bound 12 dollars; paper bound 10 dollars.

THE value of symposia increases with the amount of organization and integration of the topics which are discussed, and, all too frequently, so-called symposia become exercising grounds for well-trained hobby-horses. In "Cell, Organism and Milieu" are gathered together ten papers given at the seventeenth symposium of the Society for the Study of Development and Growth. Certainly the papers all deal with aspects of development or growth, but that is almost the beginning and the end of their connexion with each other. The book has little more coherence than a single volume from almost any scientific journal. Individually some of the papers are of great interest, but it is unlikely that they will all appeal equally to any one reader.

A review article on the physiology and biochemistry of the mammalian blastocyst rubs shoulders with papers on auxins in relation to fruit-growth and on polyploidy in root development. The first paper in the symposium, by Wilde, makes some attempt at a synthesis of the actions of some of the internal and external biochemical factors on the behaviour and development of cells, and the article ends with a description of the remarkable formation of hybrid multinucleate muscle fibres by the fusion of the cytoplasms of mouse and chick myoblasts. Hoffmann-Berling directs attention to the similarities and differences among the various cellular elements responsible for muscular contraction and other forms of cell movement, and emphasizes by models the universality of the relationship between adenosine triphosphate and contractile proteins. The problems of contraction and the control of contractile processes are taken up again by Csapo in relation to uterine muscle. This involves a discussion of the actions of the gonadal steroids on the cell membranes of the uterine muscle. Moog continues with a discussion of the action of cortisol on the development and activity of phosphatases, and Schneiderman and Gilbert make the suggestion that the 'juvenile hormone' in insect development is a steroid. Finally, a paper by Loomis emphasizes how science advances in water-tight compartments. The importance of carbon dioxide tension has been part of the stock-in-trade of mammalian physiologists since the days of J. S. Haldane, Sir Joseph Barcroft and L. J. Henderson. Its importance is now emphasized in relation to the growth and development of *Hydra* and other organisms.

"The Relationship between Nucleus and Cytoplasm" again emphasizes the diversity of approaches to a subject which might at first sight appear to be more restricted. The twenty papers range from a study of truth and artefact in electron-micrographs of the nuclear membrane and the mitotic spindle (Lehmann), and of the various cytomembranes and their associated granules (Bernhard), through the fascinating story of the injection of ordered genetic material into bacteria during the mating process of *Escherichia coli* (Jacob), the results of the transfer of nuclei of different ages of embryo (Fischberg, Gurdon and Elsdale) and of different species (Moore) to enucleate ova, to studies of the different cytochemically distinguishable constituents of the nucleus during development and in different functional states of a wide variety of cells (Alfert). Other papers include one on the use of autoradiographs to determine the pattern of keratin synthesis in an epithelium by the use of sulphur-35-DL-cystine, in which there is some evidence that the nucleus is the first part of the cell to be involved (Pelc), another on their use in the synthesis of chromosome material (Ficq, Pavan and Brachet), and another on the use of chromatography to determine the patterns of amino-acids which develop in normal sea-urchin embryos and in those resulting from interspecific crosses. In the last, the amino-acid pattern is shown to be primarily maternal, even though paternal morphological characters may have appeared.

The dominant note which resounds from both symposia is that cellular behaviour and development result from a very intimate inter-relationship between nucleus, cytoplasm and environment, and that cells can no longer be regarded as being dominated entirely by nuclear influences.

E. N. Willmer

Evaporation and Droplet Growth in Gaseous Media

By N. A. Fuchs. Translated from the Russian by J. M. Pratt. Edited by Dr. R. S. Bradley. Pp. vii+72. (London and New York: Pergamon Press, 1959.) 30*s*.; 5.50 dollars.

DROPLET evaporation in gaseous media is important in a wide range of problems such as the formation of cloud droplets, the evaporation of fuel in the internal combustion engines and in particular in fogs and atmospheric pollution. This book is a translation from a Russian paper by N. A. Fuchs, who himself has made most important contributions towards this subject. The treatment is largely mathematical, but a particularly valuable aspect of the work is the critical review of the whole of the experimental work in this field.

Fuchs considers evaporation and droplet growth in three chapters, of which the first is concerned with drops which are motionless with respect to the gaseous medium and thus no hydrodynamic factor is present. Chapter 2 deals with drops moving in relation to the gaseous medium—described as quasi-stationary evaporation—while the final chapter deals with non-stationary evaporation of drops in which the droplet is moving about in the gaseous medium.

In the first chapter, the basis of the theory is that put forward by Maxwell in an article on diffusion written in 1877 for the "Encyclopædia Britannica", and from this a rate of evaporation equation is developed. The influence of the Stefan flow on the rate of evaporation of drops is discussed, and also the influence of concentration change at the surface on the rate of evaporation. The fall in temperature is next considered both for freely evaporating drops and for supported evaporating drops with a very complete review of the experimental work.

As regards evaporation and the growth of drops moving relatively to the medium, Fuchs used the relationship which has been developed between the Sherwood and the Reynolds and Schmidt groups and discusses the effects of the diffusion and the rate-boundary layers.

F. H. GARNER

Boundary Problems in Differential Equations

Proceedings of a Symposium conducted by the Mathematics Research Center at the University of Wisconsin, Madison, April 20–22, 1959. Edited by Rudolph E. Langer. Pp. x+324. (Madison, Wisc.: University of Wisconsin Press, 1960.) 4 dollars.

THE Mathematics Research Center of the United States Army, founded in 1957, is directed by Prof. R. E. Langer of the University of Wisconsin; it has its permanent home in a new building in the center of the campus of that University. The scientific staff of the Center, numbering about thirty, consists in the main of mathematicians (not all American citizens) on leave from other institutions, who are free to work in any fields they please, though they may be called on by the U.S. Army for professional advice.

The principal interests of the Center are in numerical analysis, statistics and probability, analysis and classical applied mathematics, operations analysis. To increase interest in these fields, the Center held a three-day symposium in 1958 on numerical approximation, another in 1959 on boundary problems in differential equations, and proposes to hold more on similar subjects. The papers read at the 1959 symposium are now available in book form. Because of the shortage of time, the field of discussion was restricted to boundary problems for ordinary and partial differential equations. Even though initial value problems were excluded, the field is very wide. The nineteen papers, six of which were given by visitors from Europe, differ greatly in outlook. Some deal with numerical methods, others are in the strict tradition of classical analysis; a few made use of the more modern approach using fixed-point theorems for operators on a topological space. While some of the work has been published in more detail elsewhere, the book is, nevertheless, a useful addition to the literature of differential equations.

E. T. COPSON

Topographical Anatomy of the Dog

By Dr. O. Charnock Bradley. Sixth edition, revised by Prof. Tom Grahame. Pp. xiv+332+21 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1959.) 36*s*. net.

THIS well-known book, now in its sixth edition, has retained its essential character as a systematic guide to the dissection of the dog. The general plan consists of a description of the various anatomical regions, including short, easily followed, dissection instructions. Thereafter the spinal cord, brain and lymphatic system are described, and finally useful tables of arteries and cranial nerves are added. The nervous system has been elaborated in the present edition, and there is an excellent brief account of the autonomic system. The text is concise and easily followed, and there are numerous illustrations, many of which are in colour. There is also a considerable number of radiographic plates of high quality, including several excellent injected specimens.

Prof. Grahame has to be congratulated for successfully revising this work to meet the requirements of modern veterinary practice, and there is no doubt that it will retain its established position as an essential text-book and guide to dissection. The book is very well produced, and the publishers are also to be congratulated for the high quality of their work.

T. NICOL

Ecological Processes

By Dr. Alan Mozley. Pp. xi+68. (London: H. K. Lewis and Co., Ltd., 1959.) 9*s*. net.

THE title of this book somewhat belies its contents. Far from being a generalized account, it is concerned with a few specific ecological problems considered mainly in the light of their influence on molluscs. These problems include certain aspects of ecological succession, population ecology and animal movement. The length of the book (68 pages) gives a fair indication of the depth of treatment: the text is almost entirely descriptive. Various references to other works are included, but these are few in number and scarcely make up for the general superficiality of the writing. It is somewhat surprising to find that the splendid work of Goodhart, Cain and Sheppard on populations of *Cepaea* is not even mentioned.

All things considered, it is a little difficult to see what prompted the writing of this book. Nor does the author's final "conclusion" help to throw much light on the matter—"study the ecological organization of the community, then alter it. In other words, study the ecological processes, plot their course, and modify them as necessary". W. H. DOWDESWELL

THE INTERNATIONAL CO-ORDINATION OF TIME SIGNALS AND STANDARD FREQUENCY TRANSMISSIONS

By Dr. L. ESSEN, O.B.E., F.R.S.
National Physical Laboratory, Teddington, Middlesex

IT was announced recently that plans have been made to co-ordinate the time-signals and standard frequencies transmitted in the United Kingdom and the United States. Such co-ordination has become possible as a result of the steady and remarkable developments in the precision of time-keeping which have taken place during the past decade. A recapitulation of these developments will show how co-ordination has now become possible and why it will be advantageous.

Observatory Time Signals

Time signals have been transmitted from powerful radio stations for more than thirty years. The Royal Greenwich Observatory signals, for example, are transmitted from Rugby on a number of wavelengths. They consist of a five-minute series of seconds dots from 0955 to 1000 G.M.T. and from 1755 to 1800 G.M.T., the minute signals being lengthened for identification purposes. Such signals serve two functions. They give the time of day, which is a measure of the position of a point on the Earth's surface relative to the Sun, and also the unit of time, which is required for a wide field of physical measurements. The determination of time and the unit from astronomical measurements are complex processes. The observations need to be smoothed by means of clocks, such as quartz clocks, and many corrections have to be applied. The exact times represented by the signals can only be published in retrospect ; the final values are to some extent an estimate, depending on personal judgment, and they are not necessarily the same for all observatories. Nevertheless, the unit of time has for many years been known to about 1 part in 10^8, or 0·001 sec. per day.

Standard Frequency Transmissions

Frequencies cannot easily be measured by means of the ordinary time signals. For example, if the seconds dots are accurate to 1 m.sec. it would be necessary to count vibrations for a whole day to obtain their frequency with an accuracy of 1 part in 10^8, which is the order of accuracy now required in the control of radio stations. Standards of frequency are therefore maintained in continuous operation and calibrated in terms of time signals extending over periods of months. Any other frequency can be measured in terms of the standard by simple techniques, which give a high precision in a short time. For example, two frequencies of nominal value 10^5 c./s. but differing by 1 c./s. can be compared with a precision of 1 part in 10^8 in a measurement time of a few seconds.

Standards of frequency have become elaborate pieces of equipment requiring careful maintenance, and there are therefore good grounds for making them serve a wide area by means of radio transmissions. Experimental transmissions were made in both Great Britain and the United States in the period between 1920 and 1930, and at the International Telecommunications Conference in 1947 the frequencies 2·5, 5, 10, 15, 20, and 25 Mc./s. were allocated to standard frequency services. There are now a number of continuous programmes of transmissions on some of these frequencies, the best known of which are those from Beltesville (near Washington, D.C.), having the call sign *WWV*, and from Rugby, having the call sign *MSF*. Such transmissions have been actively encouraged by the International Union of Scientific Radio with the ultimate object of giving a well-received signal anywhere in the world at any time.

The carrier frequencies are controlled by a standard of frequency and various modulation tones are added. It is generally found that the most useful of these are the 1-sec. timing pulses consisting of 5 cycles of a 1,000 c./s. tone obtained by dividing the frequency of the standard. The seconds intervals thus represent 10^5 cycles of the standard (when as in Britain it consists of a 10^5 c./s. quartz oscillator) and they can under good conditions be read with a precision of 10 μsec.

Doppler Effects and Very Low Frequency Transmissions

The full accuracy of the transmissions in the allocated high-frequency bands is obtained only in the small areas near the transmitters where the ground wave is received. At greater distances, where the wave is received after reflexion from the ionosphere, the received frequency may differ from the transmitted frequency by as much as several parts in 10^7 owing to Doppler effect changes caused by movements of the reflecting layers[1]. The effects are particularly severe at sunrise and sunset, and are least when there is a complete daylight path between the transmitter and receiver.

It is known that the propagation conditions for very low frequencies are relatively stable, and a transmission of 60 kc./s. was added to the *MSF* (Rugby) programme in 1951. In early measurements it was shown to have a stability of ± 2 parts in 10^9 at Teddington (distance 120 km.), and Pierce[2] later estimated that the average frequency for the whole transmission period of 1 hr. was accurate to ± 3 parts in 10^{10} at Cambridge, Mass., U.S.A. (distance 5,200 km.).

In view of these encouraging results, the Post Office Engineering Department controlled the carrier frequency of the powerful *GBR* 16 kc./s. transmitter from the quartz oscillator used for the *MSF* transmissions, and the signals received from this station have been studied in detail by Pierce[3]. He concluded that the Doppler shifts at sunset and sunrise were about 2 parts in 10^9, and that in the daytime the mean

Doppler shift is probably less than 1 part in 10^{10}. Somewhat greater Doppler shifts were, however, found with this transmission received in New Zealand.

At the beginning of 1960, a stable very low frequency transmitter was put into operation by the United States. This is a station at Summit in the Canal Zone with the call sign *NBA* and a frequency of 18 kc./s. Precision measurements can now be made, therefore, on signals crossing the Atlantic from west to east as well as from east to west.

The Atomic Clock

The high accuracies achieved over great distances using very low frequency transmissions were at first only accuracies of comparison, absolute values being limited by the uncertainty of the value of the unit of time. This situation was changed by the introduction of the atomic clock[4,5], which enabled frequency and time intervals to be determined and made immediately available with an accuracy of ± 2 parts in 10^{10}. It thus became possible to express frequency and time directly in terms of an atomic constant. It is obviously important to ascribe a value to this constant which makes the units of atomic and astronomical time agree. The variations of the mean solar second (or, more precisely, the unit of the time system U.T.2) are, however, more than a hundred times greater than the accuracy already achieved with the atomic standard, and a more important relationship is therefore that between the atomic standard and the second of Ephemeris Time[6,7]. This has been determined by a joint programme[8] between the U.S. Naval Observatory and the National Physical Laboratory extending over three years, and the value for the cæsium F,m (4,0) $\rightleftharpoons$ F,m (3,0) resonance at zero field is 9 192 631 770 $\pm$ 20 c./s. The cæsium standard can be used with the precision of ± 2 c./s. and the above value of frequency with these closer limits is being used as a unit of atomic time, although a value must ultimately be adopted by international agreement. Corrections for time signals in terms of a scale of atomic time have been published by the U.S. Naval Observatory since January 1957.

Co-ordination of Time and Frequency Services

As we have seen, the two kinds of service were developed independently to serve different purposes, but the 1 c./s. pulses on the standard frequency services became increasingly used as time signals and the times of the leading edge of the pulse in terms of U.T.2 were therefore published by the observatories. There were thus in the United Kingdom, for example, two systems of time signals in operation, and it would clearly be advantageous to the user if they could be co-ordinated. Such co-ordination, however, presented some difficulties because the second of Ephemeris Time, on which the frequency transmissions are based, differs considerably from the unit of the scale of uniform time (U.T.2), on which the time signals are based. This problem was discussed at the General Assembly of the International Astronomical Union at Moscow in 1958, and a method suggested there was put into operation on *MSF* (Rugby) in April 1959 (ref. 9). The frequency was offset by -170 parts in 10^{10}, the difference between Ephemeris Time and U.T.2 during 1958. Since the offset was previously announced, it presented no inconvenience to those wanting the time intervals in Ephemeris Time, or atomic time, and the 1 c./s pulses remained fairly close to U.T.2.

The co-ordination was taken a stage further in April 1959 through the co-operation of the Royal Greenwich Observatory, the Post Office Engineering Department, and the National Physical Laboratory[10]. The 1 c./s. pulses from the *MSF* quartz standard are now used to generate the Observatory time signals, so that all the signals from the United Kingdom mark identical intervals of time and, apart from the slightly different delay times in the control circuits, are accurately in synchronism. If the difference between the units of Ephemeris Time and U.T.2 is not equal to the predicted value, there will be a cumulative deviation from U.T.2 of the time pulses on all the services. These deviations will be removed by a step adjustment of 50 m.sec. made at 0000 G.M.T. on the first of the month. It is not anticipated that there will be more than one or two such adjustments per annum, and they can easily be taken into account in the determination of atomic time.

Similar steps have been taken to co-ordinate the time and frequency services in the United States[11].

International Co-ordination

It would be a great convenience to users if there could be a single service having a world-wide coverage; but although this is approached by stations such as *GBR*, the highest precision is obtained only when there is a daylight path between the transmitter and the receiver. A number of stations spaced at, say, 120 degrees of longitude around the Earth and all having exactly the same frequency and sending 1 c./s. pulses with a fixed phase relationship would resemble a single station and would overcome the Doppler effect at sunrise and sunset.

If the controlling standards are governed by a cæsium atomic standard, it should ultimately be possible to ensure that the frequencies are equal to within ± 1 part in 10^{10}, but at present they may differ by a few parts in 10^{10}. The authorities in the United Kingdom and the United States will remove any such difference by mutual agreement.

The propagation time of the time signals makes it impossible to synchronize them at every point. It has been agreed, however, that the times of emission should be the same. If, for example, a step adjustment is found to be necessary, it will be made at an agreed time and by the same amount.

The experimental co-ordination now in progress will reveal any small residual propagation errors and give valuable information on the feasibility of providing time and frequency services which can be utilized throughout the world without the application of subsequent corrections.

This article is published by permission of the Director of the National Physical Laboratory.

[1] Essen, L., *Proc. Inst. Elec. Eng.*, **101**, Pt. III, 249 (1954).
[2] Pierce, J. A., Mitchell, H. T., and Essen, L., *Nature*, **174**, 922 (1954).
[3] Pierce, J. A., *Proc. Inst. Rad. Eng.*, **45**, No. 6, 794 (1957).
[4] Essen, L., and Parry, J. V. L., *Phil. Trans. Roy. Soc.*, A, **250**, 45 (1957).
[5] Holloway, J. A., Mainberger, W. A., Reder, F. H., Winkler, G. M. R., Essen, L., and Parry, J. V. L., *Proc. Inst. Rad. Eng.*, **47**, 1730 (1959).
[6] Spencer Jones, H., *Nature*, **177**, 744 (1956).
[7] Clemence, G. M., *Science*, **123**, 567 (1956).
[8] Markowitz, W., Hall, R. G., Essen, L., and Parry, J. V. L., *Phys. Rev. Letters*, **1**, 105 (1958).
[9] NPL Announcement, *Electronic and Radio Engineer*, **36**, 117 (1959).
[10] NPL Announcement, *Electronic Technology*, **37**, 90 (1960).
[11] NBS Announcement, *Proc. Inst. Rad. Eng.*, **48** (Jan. 1, 1960).

THE NATIONAL PHYSICAL LABORATORY

THE work of the National Physical Laboratory, on show to visitors from industry, the universities and Government departments during May 25–26, covered a wide field in basic, chemical and engineering physics, metallurgy and mathematics. Items of both fundamental and applied research in all these branches were displayed.

The Laboratory is best known for its work in establishing and maintaining the fundamental British standards of various physical quantities, but in fact this only accounts for a small proportion of the total effort, and much of the work of the nine scientific Divisions is concerned with basic research on topics of immediate or potential value to industry.

The subject of noise measurement, for example, is becoming of public importance, and in the Applied Physics Division the problem of predicting the relative annoyance of sounds to the average listener is being tackled. For traffic noise a sound-level meter, using a microphone, amplifier and output meter, and with the subjective aspect covered by a frequency weighting arrangement, is likely to be the subject of an international agreement. Such a method is, however, a compromise between accuracy and expediency. Work at the National Physical Laboratory shows that the meter agrees with subjective measurements only within a restricted frequency-range. Subjective records of aircraft noise, made at last year's Farnborough Air Show, showed that for a given loudness a large number of observers judged a jet plane to be more disturbing than a piston-engined machine. This result could only have been predicted by a method of sound analysis requiring a number of different noise groupings, and therefore too elaborate for general practical testing. Work is also in progress to establish an International Standard for the normal threshold of hearing, the first necessity being an agreed design for a pure-tone audiometer.

In most fields the aim of research is to eliminate the subjective judgment, and in the Autonomics Division an interesting exhibit on the mechanical recognition of printed characters was shown. Previous systems for doing this have relied on a comparison of the specimen with ideal letter forms. In the exhibit, however, the degree of register between the unknown and its own image is continuously measured (*a*) in a rotary, and (*b*) in a transverse scan, by a light-transmission system. The output from a photocell then gives a characteristic wave-form for each character.

The possibility of an ultra high-speed computer is dependent upon reducing the switching-time in the individual elements, and work on cryotrons at liquid-helium temperature was shown. These devices depend on the difference in temperatures at which two metallic elements, in this case lead and tin, become superconducting. The magnetic field set up by a current through one of them restores resistivity in the other. Switching times as low as 10^{-8} sec. have been recorded. The devices are prepared by metal evaporation as in printed circuit techniques, silicon monoxide being laid down for intermediate insulating layers. The main problem is to achieve reproducibility in performance for large numbers of a single design. A possible computer element embodying about 170 cryotrons on a sheet 5 in. × 2½ in. was shown.

Operation of the Laboratory's existing computer facilities, *Ace* and *Deuce*, is in the hands of the Mathematics Division, and several excellent examples of fruitful collaboration with other Divisions were displayed. For example, a statistical analysis of performance and design data from trawlers at sea, collected by the Ship Division, has been made on *Deuce*. As a result, six parameters have been defined, from which it is possible to predict the effective horse-power-speed curve for a given design. Trawlers have already been built incorporating improvements indicated by these same parameters, and these have shown outstanding rough-weather performance. In a similar way, improvements of 10–20 per cent in resistance have been obtained in the case of models. Computer work is also being done on curve-fitting to the hull surface of a ship, with the view of eliminating the full-scale fairing of a ship's lines on the mould loft floor.

The behaviour of ships in rough sea conditions is also being studied in a 100-ft.² sea-keeping basin at the new Ship Hydrodynamics Laboratory at Feltham. A 10-ft. radio-controlled model of a trawler design was shown in operation at speeds up to 10 ft. per sec. in a wave system from a wave-maker along one side of the basin. Ultimately, it is intended to fit a transverse wave-maker for the generation of confused sea states. The model makes simultaneous records—film or digital—of roll, pitch, heave, torque, time, thrust, shaft speed, helm and heading. At the same time, the position of the model is fixed by means of an ultrasonic pulse, which by time of transit gives a bearing to three shore stations.

The Aerodynamics Division, in addition to fundamental work on high-speed flight, also devotes a considerable effort to industrial aerodynamics, and a low-speed wind tunnel, with 7-ft.² section and a balance for simultaneous measurement of pitching, rolling and yawing, has been converted for such tests. The phenomenon of 'vortex shedding' can, at particular wind velocities, lead to dangerous oscillations of structures, and models of two tall chimneys were shown in an airstream. One of these was fitted with three helical strakes and the oscillation was shown to be eliminated. A similar type of problem is the oscillation of banks of parallel tubes such as heat exchanger tubes in a high-velocity gas stream. By means of films of a scale model of such a bank, studies have been made of the nature of the oscillation and its relation to various parameters.

A model of a single span of the proposed Severn suspension bridge was shown under test. The design is one of several possible ones which are being tested for compatibility between simplicity of construction and aerodynamic stability. The model itself is rigid, but on a damped free suspension, and is scaled for mass and inertia (1 : 48) and also for the frequency ratio of vertical to torsional oscillation. Under these conditions the air-speed at which oscillations occur is directly related to the air-speed at which they

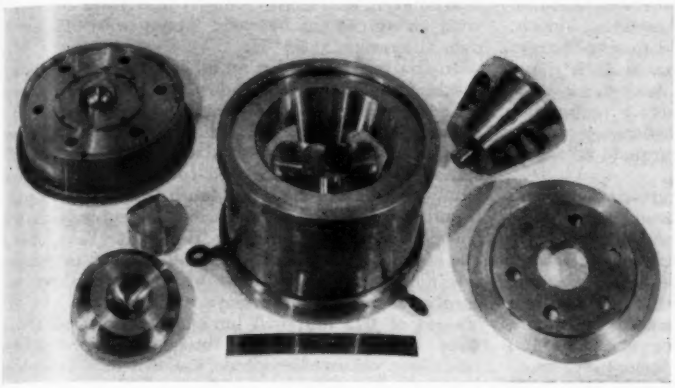


Fig. 1. Ultra high-pressure apparatus. This photograph shows the construction of the apparatus used to generate ultra high-pressures. The upper anvil is removed and the tetrahedral chamber is exposed. Crown copyright reserved

occur in the model. The latter has, in fact, been found to be stable at speeds up to 80 ft. per sec., corresponding to actual wind-speeds of 100 m.p.h.

The work in the Metallurgy Division on the fundamental mechanism of brittle cleavage fracture in single crystals of iron has been followed up by studies of the effect of orientation on the mechanical properties of polycrystalline iron. At right angles to the direction of plastic flow in rolling, the metal is not only brittle at room temperature, but also becomes progressively weaker as the temperature is lowered. This behaviour is not directly explicable in terms of the orientation effects in single crystals. The dislocation pattern of such cold-worked iron is being investigated by the examination of thin films on the electron microscope.

Brittleness in antimony–copper alloys has been connected experimentally with the presence of surface layers of high antimony concentration. The latter have been demonstrated by radioactivation, followed by the removal of successive 500-Å. layers with emery. After three such treatments both the surface composition and the mechanical properties of the metal correspond with those of the bulk material. After heat treatment for 20 hr. at 950° C., brittleness and the presence of one-third of a monolayer of antimony at the surface are restored.

Nuclear magnetic and electron-spin resonance are being used for studies of the fundamental properties of materials, particularly polymers, in the Basic Physics Division. Preliminary work on solids at extremely high pressures has been carried out in an apparatus consisting of a tetrahedral arrangement of four tungsten carbide anvils (Fig. 1) subjected to hydraulic pressure (200 tons load). The centre tetrahedron (side-length 0·75 in.) of pyrophyllite, which transmits the pressure hydrostatically to the specimen (0·3 in. × 0·1 in. diam.), can be seen dismantled in Fig. 2. Connexions for measuring resistance, temperature, or for heating the specimen, are made via the anvils. In preliminary work pressures of 77,000 atm. have been attained, as shown by observation of the resistivity transition point of barium metal. With the apparatus it is intended to study the effect of pressure on the properties of semiconductors.

For pressures of more normal industrial interest, in the 5–10,000 atm. region, pressure balances have been calibrated to a few parts in 100,000. The correction to be applied for elastic deformation of the piston–cylinder assembly has been determined by measurements with two assemblies of materials of different elastic constants (steel and aluminium bronze) in opposition, and also by determining the rate of flow of liquid between piston and cylinder at different pressures. The two methods give very closely agreeing results. This work will also be used to study the crystal and electronic transitions of the various elements under pressure.

Engineering requirements have always been prominent in the programme of the Standards Division. A 450 tonf. secondary standard load cell incorporates nine 50 tonf. struts, each of which is calibrated on a deadweight machine. Each strut has eight strain gauges connected in pairs to bridge circuits, the outputs from which are fed to a digital recording circuit capable of an accuracy of $\pm$ 5 μV. in 2,500 μV.

The same Division, with its tradition of high-precision metrology, is well equipped for the construction of a new primary standard of mutual inductance, one of the two basic instruments for deriving electrical quantities from the fundamental units of length and time. The design follows the

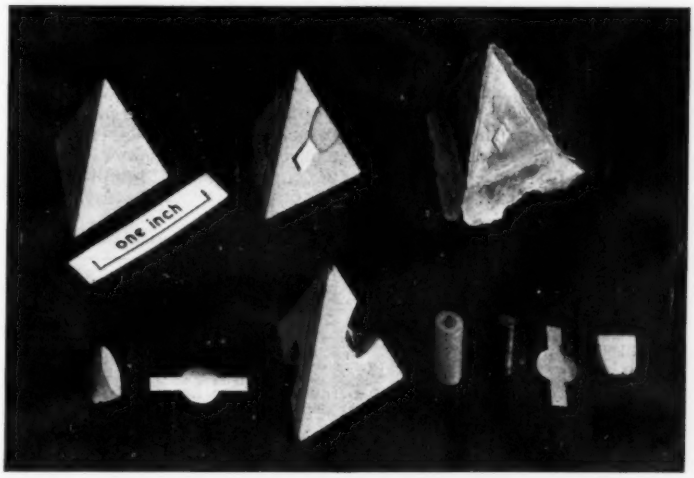


Fig. 2. Ultra high-pressure apparatus. This photograph shows samples of the pyrophyllite tetrahedra. At the upper right is one which has been loaded and shows the gasket formation; the lower position is an exploded view of the assembly and shows the test samples, the silver chloride sleeve, electrical contacts and the completing pieces of the pyrophyllite tetrahedon. Crown copyright reserved

original one of A. Campbell, with two coaxial helices, separated by a gap equal to their combined length, wound on a helical groove in a fused quartz former. A secondary of many turns is situated in a plane midway between the helices. With modern methods of metrology, including interferometric techniques for length, it is hoped to realize considerably greater accuracy in the dimensions of the complete assembly than in the earlier standard.

A new field in which there is a growing demand for a high precision is the measurement of temperatures in the region 10–90° K., and a helium gas thermometer used for such purposes was on show. The helium is contained in a constant volume, changes in pressure being measured as changes in capacity by movement of a thin metal diaphragm. Fixed points are the boiling points of oxygen (*c.* 90° K.) and hydrogen (*c.* 20° K.), and work is in progress to realize the triple point of oxygen (*c.* 54·4° K.). It is thus hoped to extend the International Temperature Scale below the present limit of 90° K. Platinum resistance thermometers, calibrated against the helium thermometer, have been compared with others from the National Bureau of Standards, Washington, and from Pennsylvania State University with an agreement between laboratories of ± 0·02° over the range 20–90° K.

In the Light Division an attempt is being made to establish an absolute standard of luminous intensity without reference to a black body radiator. The response of a photocell is calibrated in volts per watt of incident radiation in an absolute radiometer. The same photocell is then used to measure the output from a secondary standard lamp (2,042° K.), using a liquid filter designed to give, in combination with the photocell, the same relative spectral response as the standard photometric eye. The same experiment has also been carried out with a filter–thermopile combination (the lamp temperature being 2,854° K.). Values of 673 and 676 lumens per watt at 0·555μ were obtained. The theoretical figure, depending on the values accepted for various constants in the temperature scale, is within the range 670–686.

The foregoing are chosen from more than 170 topics on display, which in turn represented only a proportion of the wide range of the total programme of the Laboratory. H. G. Short

FINAL MONTHS AND DESCENT OF SATELLITE *SPUTNIK* 3

By B. R. MAY and D. E. SMITH

Radio Research Station, Department of Scientific and Industrial Research, Slough

NOW that the satellite *Sputnik* 3 has descended, it is possible to review the last months of this satellite's existence, which ended on April 6, and to outline the main features of its 692-days lifetime, in which it performed some 10,037 revolutions and travelled more than 280 million miles.

Previous articles[1,2] reviewed the satellite's progress up to the end of April 1959, and we may now show the mean nodal period–time curve from the beginning of May 1959 until its descent (Fig. 1). It follows generally the expected shape, the slope increasing steadily from about 1·0 sec./day on June 31, 1959, to 1·8 sec./day on October 31, and to 2·5 sec./day on January 31, 1960. Since the beginning of May 1959 the perigee moved (in a direction opposed to the orbital motion of the satellite) from southern apex towards the equator, where it was on January 11, 1960, and had reached nearly 40° N. when the satellite descended.

Table 1 gives the orbital elements for *Sputnik* 3 from June 1.00, 1959, to April 1.00, 1960, obtained in the same manner as before[1]. The calculations have been made for only one value of scale height instead of two, since more reliable values for the scale height at the perigee height (also included in Table 1) are now available.

The period–time curve for the complete lifetime of this satellite has been plotted in Fig. 2, and the variations in the slope of the curve indicate the constantly changing atmospheric density encountered by the satellite at its perigee. The shape of the curve is affected by the rotation of the orbit, and its departure from a regular form has created difficulties in producing predictions the accuracy of which is better than 2–3 min. at the end of a period of a week, and in estimating the date of descent of the satellite[3]. The curve also displays irregularities lasting only a few days—those which occurred during

Table 1. Orbital Elements for 1958 δ_2 (Figures in brackets are probable errors)

Date	Nodal period of revolution (min.)	Semi-major axis (km.)	Eccentricity	Perigee distance (km.)	Apogee distance (km.)	Orbital inclination (deg.)	Rate of rotation of orbital plane (deg./day)	Argument of perigee (deg.)	Scale height at perigee (km.)
1959									
June 1.00	99·127 (0·005)	7096·1 (0·2)	0·0721 (0·0005)	6584·4 (3)	7607·9 (3)	65·10 (0·01)	2·91 (0·02)	273 (1)	37 (4)
July 1.00	98·703 (0·005)	7075·7 (0·2)	0·0695 (0·0005)	6583·8 (3)	7567·6 (3)	65·10 (0·01)	2·94 (0·02)	261 (1)	37 (4)
Aug. 1.00	98·205 (0·005)	7051·7 (0·2)	0·0665 (0·0005)	6583·1 (3)	7520·3 (3)	65·09 (0·01)	2·98 (0·02)	248 (1)	36 (4)
Sept. 1.00	97·650 (0·005)	7024·9 (0·2)	0·0630 (0·0005)	6582·3 (3)	7467·5 (3)	65·09 (0·01)	3·02 (0·02)	235 (1)	36 (4)
Oct. 1.00	96·959 (0·005)	6991·6 (0·2)	0·0587 (0·0005)	6581·1 (3)	7402·0 (3)	65·08 (0·01)	3·07 (0·02)	223 (1)	36 (4)
Nov. 1.00	96·089 (0·005)	6949·6 (0·2)	0·0533 (0·0005)	6579·4 (3)	7319·9 (3)	65·07 (0·01)	3·13 (0·02)	210 (1)	36 (4)
Dec. 1.00	95·175 (0·005)	6905·5 (0·2)	0·0475 (0·0005)	6577·7 (3)	7233·3 (3)	65·06 (0·01)	3·20 (0·02)	197 (1)	35 (4)
1960									
Jan. 1.00	94·105 (0·010)	6853·9 (0·5)	0·0406 (0·0005)	6575·4 (3)	7132·5 (3)	65·05 (0·01)	3·28 (0·02)	183 (1)	35 (4)
Feb. 1.00	92·871 (0·015)	6794·3 (0·7)	0·0327 (0·0007)	6572·3 (4)	7016·4 (4)	65·03 (0·01)	3·37 (0·02)	170 (1)	34 (4)
Mar. 1.00	91·533 (0·020)	6728·4 (1·0)	0·0239 (0·0008)	6567·9 (5)	6889·0 (5)	65·02 (0·01)	3·50 (0·02)	156 (1)	32 (4)
Apr. 1.00	89·140 (0·020)	6610·5 (1·0)	0·0105 (0·0009)	6540·8 (6)	6680·2 (6)	65·00 (0·01)	3·72 (0·02)	142 (1)	26 (4)

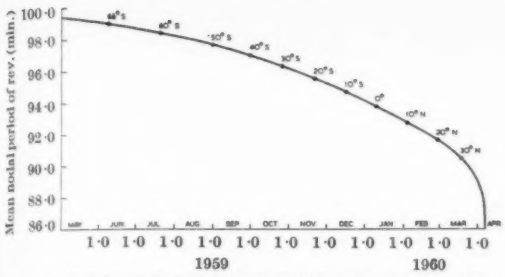


Fig. 1. Nodal period of revolution of Satellite 1958 δ_2 (*Sputnik* 3). Numbers on curve indicate latitude of perigee

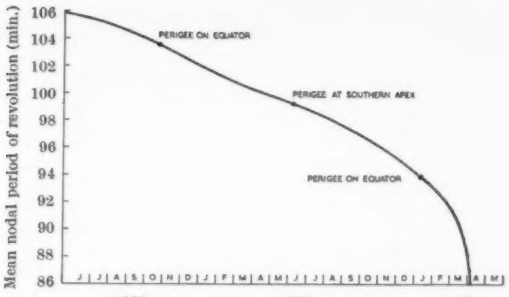


Fig. 2. Complete period–time curve for Satellite 1958 δ_2 (*Sputnik* 3)

July 15–19, August 17 and October 4–7, 1959, coincided with prominent geomagnetic storms on those dates.

The mean nodal period–time curve kept for prediction purposes, and which is accurate to 0·005 min. over the major part of the lifetime of the satellite, has been based upon optical and radio observations made mainly in the United Kingdom, Finland and France. As an object for visual observations the satellite was not very bright, and although the brightest magnitude reported was +1, the majority of observations were made at magnitudes of between +4 and +7. Due to this and the general irregularity of its brightness, the satellite was detectable only with difficulty with cameras and the more elaborate tracking instruments of small angular field, so that the majority of the 500 or so observations of time and position made in the United Kingdom were obtained by amateurs using quite modest instruments. The satellite's transmitter on 20 Mc./s. radiated during the whole of its lifetime, though after some three months it failed to transmit useful telemetry information, and from December 1959 there remained only a C.W. signal with spasmodic modulation. Since, at the time of its descent, the satellite was visible only from two narrow bands of latitudes situated near northern and southern apex, the radio transmissions provided the principal means of following its final revolutions.

Little is known about the descent of this satellite, as its suspected last transit lay mainly over the sea and unpopulated areas. The last reported visual sighting, at the time of writing, was made from Jokioinen in Finland at about 01.45 hr. U.T. on April 6, and it was unlikely that any later sighting would have been possible from consideration of the visibility conditions. Three transits later, the radio signals were picked up at Jodrell Bank, Berlin, Darmstadt and the Radio Research Station at Winkfield (where interferometer measurements were made) at about 06.11 hr.–06.15 hr. (position *A* in Fig. 3) and the last known positional radio observations were made on the following transit at about 07.30

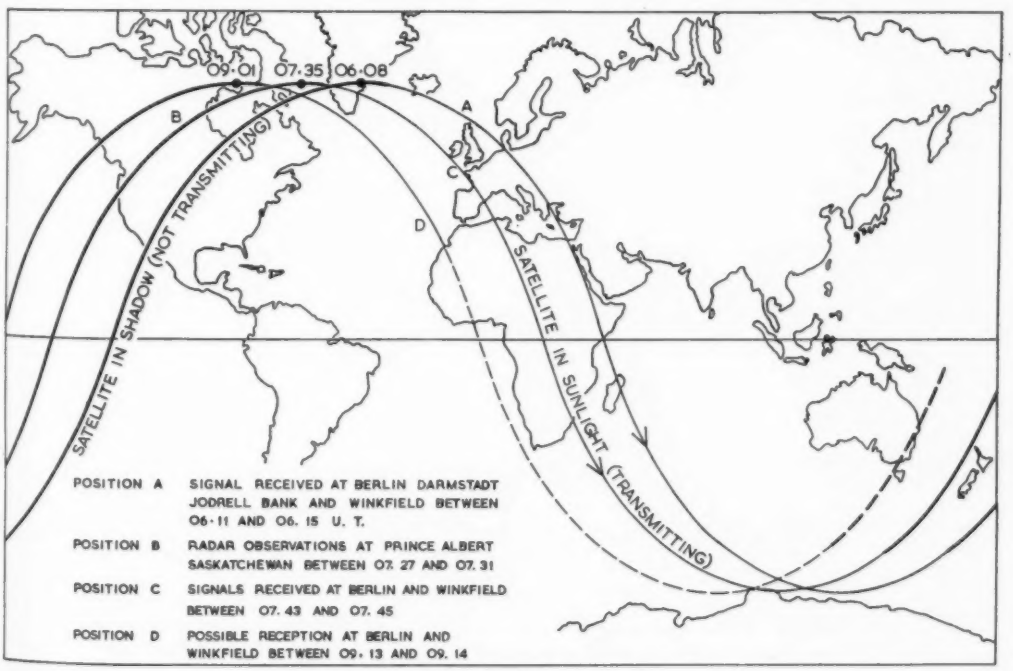

09·01
07·35
06·08
A
B
C
D
SATELLITE IN SHADOW (NOT TRANSMITTING)
SATELLITE IN SUNLIGHT (TRANSMITTING)
POSITION A SIGNAL RECEIVED AT BERLIN DARMSTADT JODRELL BANK AND WINKFIELD BETWEEN 06·11 AND 06. 15 U. T.
POSITION B RADAR OBSERVATIONS AT PRINCE ALBERT SASKATCHEWAN BETWEEN 07. 27 AND 07. 31
POSITION C SIGNALS RECEIVED AT BERLIN AND WINKFIELD BETWEEN 07. 43 AND 07. 45
POSITION D POSSIBLE RECEPTION AT BERLIN AND WINKFIELD BETWEEN 09. 13 AND 09. 14

Fig. 3. Final revolutions of Satellite 1958 δ_2 (*Sputnik* 3), April 6, 1960

from Prince Albert, Saskatchewan (position *B*), and at about 07.43 from Winkfield (position *C*). At 08.00 hr. the period appeared to be 86·8 ± 0·2 min. and from theoretical considerations the satellite would have a further lifetime of about 1–2 hr. Moreover, it has been reported that a short, faint signal at the correct frequency was heard at both Berlin and Winkfield at about 09.13 hr. (position *D* in Fig. 3), when the satellite was below the horizon from both stations. A normal half-hop transmission seems to be impossible from a consideration of the position of the satellite and its transmitting frequency, but it is possible that propagation by scattering in the ionosphere may have taken place rather than reflexion, since the ionosphere was very disturbed in this region at this time. This evidence must, however, be regarded as inconclusive.

We should like to take this opportunity of thanking all those who have sent us radio and optical observations of this satellite, thus enabling a regular flow of predictions to be maintained.

This work was carried out as part of the programme of the Radio Research Board and is published by permission of the Director of Radio Research of the Department of Scientific and Industrial Research.

[1] King-Hele, D. G., *Nature*, **182**, 1409 (1958).
[2] May, B. R., and Smith, D. E., *Nature*, **184**, 765 (1959).
[3] May, B. R., *Nature*, **185**, 729 (1960).

SCIENTIFIC RESEARCH AND DEVELOPMENT: A COMPARATIVE STUDY

By S. DEDIJER

Formerly Director of the Boris Kidrich Institute of Nuclear Sciences, Belgrade

THE scientific potential of Yugoslavia and the effort to increase it are to-day much greater than in 1940. Nevertheless, many Yugoslav scientists have felt for years that their country was neglecting science and that a sounder and a more vigorous research policy was needed. Owing to a lack of liaison between the embryo scientific community and the State nothing was done to back up these impressions with quantitative evidence. This happened also because the Government felt, by what it calls now "the logic of development", that the country could not concentrate both on the development of science and industrial production potential. In the latter case considerable results have been achieved; outside observers consider the economic development of Yugoslavia to be to-day among the most rapid in the world. Lately, however, a new, previously lacking awareness of the consequences of the 'logical' neglect of research has begun to appear in Government circles. The following statement[1], the first such made by a Yugoslav Government and Communist League leader, perhaps best illustrates the background of the recent trend toward a more vigorous research policy:

"We have posed ourselves the goal to catch up economically and culturally with the developed countries of the world and to do it as rapidly and as soon as possible. But how to do it when the world is striding forward at great speed in the midst of a scientific–technological revolution? The forces of organized scientific–technological creativity are continuously and rapidly growing and the developed countries are in a position to introduce incessantly ever new and more abundant knowledge and to create new productive forces. Under such dynamically competitive conditions a country which develops its production only on the basis of the existing, routine technology cannot reach the same goal as the most developed countries. On the contrary, such a country will unavoidably and 'systematically' lag. . . . In this sense, we are lagging behind the most developed countries."

Whether one defines it by generalizing Marx's definition of work or by using the broader concepts of cybernetics, a research policy calls for decisions on: (1) The principal goals which a society can and should reach by means of its research potential. (2) The magnitude of the 'physical' elements of the scientific potential: personnel, equipment, finances, etc. (3) The long-range research programme, that is, the distribution of the scientific potential with respect to the main social goals. (4) Time distribution of the scientific effort. (5) The social and political measures needed to make the potential both scientifically and socially productive.

Until recently Yugoslavia had very little of the information needed to make sound decisions on any of the above components of a research policy. The tables in this paper were prepared in order to estimate and illustrate how much Yugoslavia is "lagging behind the developed countries". This is done by comparing the orders of magnitude of the scientific effort per inhabitant of Yugoslavia and its economic potential with those of the United Kingdom, the U.S.S.R. and the United States.

The tables, with the appropriate comments, served as an introduction to the discussion between the representatives of science, industry and Government at a symposium on the organization of research of the First Yugoslav Chemical Congress, held in Zagreb during June 15–21. Some of the tables, with added comments of a more general kind, are presented here.

Looking through the various national statistical yearbooks one is impressed by how many countries have felt the need to count their donkeys and how few their scientists. This is because many countries are just beginning to consider what the current scientific revolution means to them. But even countries which gave birth to the industrial and the scientific revolutions have begun only recently the difficult task of measuring the various aspects of the interaction of science and society. As late as 1957, for example, the Advisory Council on Scientific Policy of the United Kingdom[2] pointed out that "this is a field in which it is difficult to obtain precise and comprehensive statistics", regretted "that comparable figures were not available for Western European countries" and warned that "although we have to some extent followed the American model in

the presentation of our statistics, any comparison should be made with considerable reserve".

To make a comprehensive comparison of the role of science in various countries one should take into account the scientific efforts, the scientific potentials and their social and scientific productivities. Yet for most of these concepts no one has devised up to now reliable measuring rods. In the case of Yugoslavia the small amount of data existing on research was based on ill-defined (if defined at all) concepts and on criteria generally unacceptable in comparison with those adopted in the developed countries. For all these reasons, the possible field of comparison was limited to a small number of research indicators on which the most elementary statistics exist in all the countries in question and to which a common set of criteria could be applied. This also limited the comparison to the year 1957. The indicators are: (1) The annual expenditure on research and development. (2) The number of scientists and engineers. (3) The annual production of engineers and scientists. (4) The expenditure on research in various industries.

The necessity to limit ourselves to these indicators of the scientific effort and potential has biased the comparison in favour of Yugoslavia. For they do not tell us anything about the scientific and social productivity of the research policy. The countries with which we are comparing Yugoslavia's scientific effort and potential have had experience with research for tens and even for hundreds of years, and have been aware of the economic and social consequences of the scientific revolution much longer than Yugoslavia. Let us take, for example, one hundred young men entering a branch of research in one of the three developed countries and a hundred in Yugoslavia. The first hundred were trained in universities where research has a long tradition. They are only another hundred research workers becoming a part of an existing scientific potential with a long tradition. The hundred Yugoslavs come from over-crowded, under-staffed and under-equipped universities, where, everyone in Yugoslavia readily admits, research is neglected by tradition and until recently by policy. Most likely, they are the first hundred research workers in the given branch; and they are to work as a part of an embryo scientific community with many negative and few positive inherited traits. All this is not conducive to make the Yugoslav hundred into a highly productive nucleus in the given branch. Thus, were we to compare the results obtained from a given investment in research, the comparative picture would be much less favourable to Yugoslavia than the tables indicate.

To avoid the risk of under-estimating the scientific effort of Yugoslavia, the maximum figures and the most favourable variants were taken and the same criteria as in the developed countries were applied. Thus, in estimating the number of university teachers engaged in research, the same criteria were used as in the United States and the United Kingdom, although this is quite unrealistic. Also, whenever there was any doubt if a sum of money had already found its way into the "research expenditure of Yugoslavia", it was added anew rather than risk to omit it. Hence, the probability of the error in the Yugoslav figures on research being plus is equal to 0. The probable errors for the corresponding data for other countries are not given, simply because, with a single exception, the sources do not quote them. This, however, is not vital since we are only comparing the orders of magnitude of scientific efforts.

The general sources of all the data are given at the end without quoting them for each particular figure. The Soviet data on research expenditure were taken from Western sources.

Yugoslavia's lag in research in 1960 is probably greater than Table 1 shows for 1957. For, according to one estimate, except in nuclear energy, Yugoslavia is not spending more on research in 1960 than in 1957. The United States, on the other hand, has increased its expenditure in 1959 by about 50 per cent over 1957, while the U.S.S.R. has increased it in 1960 by 15·4 per cent over 1959 [3].

Table 1. Expenditure on Research and Development per Inhabitant (1957)

	(American dollars)	(Relative)
United States	47·9	53·2
U.S.S.R.	26·5	29·4
United Kingdom	18·2	20·1
Yugoslavia	<0·9	1
British Colonies	0·05	1/18

To illustrate the dynamics of growth of the scientific effort we have chosen the United States (Table 2) because the statistical data are most easily available.

Table 2. Dynamics of Growth of the Scientific Effort (United States)

Year	Electrical energy	Steel	Expenditure on research and development
1945	1·0	1·0	1·0
1950	1·4	1·2	1·8
1951	—	1·3	2·2
1952	—	1·2	2·5
1953	—	1·5	2·6
1954	—	1·1	2·7
1955	2·3	1·5	3·6
1956	—	1·5	4·3
1957	2·6	1·4	5·4
1958	2·7	1·1	6·6
1959	—	—	8·2

Table 3 is least satisfactory from the point of view of method. It has been assumed that what in Yugoslavia is called 'social product' and 'national economy investment' corresponds to the gross national product and fixed capital formation used in the United States and the United Kingdom. Some Yugoslav economists estimate that the gross national product is by definition about 10 per cent greater than the 'social product'. If we actually used the gross national product, the figure 0·5 per cent for Yugoslavia would be even smaller. The Soviet figures were obtained from ref. 4.

It would have been illuminating if the tables contained data from countries equally or less economically developed than Yugoslavia. It is significant, although unfortunate, that such material seems scarcely to exist in the published literature—if at

Table 3. Portion of Gross National Product spent on Research and Development and Gross Fixed Capital Formation (1957)

	Research and development expenditure as per cent gross national product	Fixed capital formation as per cent gross national product
Yugoslavia	<0·5	27·5
U.S.S.R.	2·1(?)	15·0(?)
United Kingdom	1·7	15·5
United States	1·9	17·4

Table 4. Comparison of the Economic Development and Scientific Effort per Inhabitant (1957) (Relative)

Country	Electrical energy	Total energy	Steel	Sulph. acid	Cement	Shoes	Dollars for science
Yugoslavia	1	1	1	1	1	1	1
U.S.S.R.	3·1	4·2	4·4	3·3	1·3	1·4	29·4
United Kingdom	5·2	8·1	7·2	6·7	2·1	2·5	20 1
United States	12·2	14·8	10·3	12·8	2·8	3·1	53·2

Table 5. Scientists and Engineers per Inhabitant (1957) (Relative)

Country	Scientists, engineers in research	Engineers in industry	Graduating	
			Engineers	Scientists
Yugoslavia	1	1	1	1
U.S.S.R.	5·5	11·1	5·7	1·8
United Kingdom	4·0	3·6	1·9	3·3
United States	7·1	8·3	2·5	5·9

all. For this reason in writing about the undeveloped countries, as one author has said, one is prone to commit the well-known sin of over-generalization and under-documentation. This sin of 'feigning hypotheses' will not be avoided in the comments to the tables.

Whether there is a general 'logic of development' which makes undeveloped countries neglect research, as evidently Yugoslavia has done up to now, is difficult to say. But some of the few economists who have considered the role of research in economic development seem to agree that "There is no doubt that one of the main deficiencies of underdeveloped countries is their failure to spend adequately upon research and upon the development of new processes and materials appropriate to their circumstances"[5]. From Table 3 and the available inadequate, partial evidence from other countries, one could reformulate W. A. Lewis's words as a quantitative 'law': "The higher the economic development of a country, the greater is the percentage of the gross national product invested in research".

This 'law' actually represents a new definition of an undeveloped country in the scientific revolution era. It would be worth while to analyse the causes of this 'law' by all the methods available to social science. Here we shall only point out some of the consequences of such neglect of research.

As Marx would have put it, research lowers the 'exchange value' and increases the 'use value' of the existing goods; it creates completely new 'use values' by creating new products for new needs. Thus, for example, in the United States, "about 41 per cent of the manufacturing industries research money is spent on the improvement of present products, 48 per cent on new products and only 11 per cent on new processes"[6]. Research increases the productivity of labour; according to one source[7] almost 1 per cent of the annual increase of productivity of labour of 2·2 per cent in the United States is due to research. By neglecting research an undeveloped country has to leave it to others to transform its raw or semi-fabricated materials into new or better kinds of products, which it will have to buy. At the same time, it will continue to spend more labour per unit product than the countries which encourage research. Thus it continues to be an object of exploitation in the world market.

To cope with the "dynamically competitive conditions" of the scientific revolution mentioned by Mr. Popovich, a country must start to develop research simultaneously with its economic potential. For although research expenditure constitutes a small percentage of the gross national product, it takes considerable time to translate it into tangible results. To transform a laboratory result into an economically successful commodity takes on the average 5–10 years. It takes at least 10 years to train a talented secondary school graduate for research. The time needed to create 'tradition', that is, the atmosphere necessary for productive scientific work, is much longer. It follows that the results of neglecting research will be felt only when it may prove too late to cope under competitive conditions.

Some of the noticeable characteristic traits of science in undeveloped countries can be attributed to the neglect of research; such as, for example, the neglect of research in the universities. From the official figures on research expenditure in the universities, one can conclude that Yugoslavia spends not much more than 1 per cent of its research funds there. This is several times less than in the United States and the United Kingdom. At the same time that the universities are starving for research funds, the research institutes are thriving. That Yugoslavia is not alone in this is shown by the following resolution of the physics teachers of India[8]: "As the main burden of training future physicists must be borne by the universities, the Universities Grant Commission is requested to ensure that the emoluments, research grants and other facilities available to the universities teachers are adequate and in no way inferior to those available to people in similar positions in the National laboratories or elsewhere". There is evidence that scientists in Yugoslavia and India are not alone in feeling this way.

In listing a set of decisions constituting a research policy, perhaps the most important was put last. This can be seen from the following words of Prof. Polanyi in *Science* in 1950, illustrating something encountered by anyone who has studied this or that phase of developing science in one or several new countries.

"Those who have been in those parts of the world where the life of science is just beginning, know the tremendous difficulties and the struggle which the lack of scientific tradition imposes upon the pioneers working to found science in these countries. On one hand the research work is stagnating because of lack of encouragement, and on the other it is developing completely chaotically for the lack of any kind of directing influence. Unsound reputations spring up like mushrooms, founded on nothing or on the commonest results, or often on empty boasting. The political and economic interests influence to a large extent the nominations to important positions and in deciding on funds for research. No matter how great is the local talent, such an environment will not make it possible for it to develop" (translated from Yugoslav).

This illustrates only some of the aspects of a lack of transfer of information inside a research community and between it and the other sectors of society, such as industry, Government and others, which must participate in formulating a research policy. Such a lack of information, among other matters, gives rise to the 'nuclear myth', so prevalent in undeveloped countries. There is a fair amount of qualitative evidence that in some of these countries the expenditure on nuclear physics and nuclear energy research is many times greater than in the fields of utmost economic importance. In the case of Yugoslavia there is also quanti-

tative evidence. Thus, for example, from Table 6 presented at the symposium (not published here) one can estimate that in the next five years Yugoslavia now plans to spend about ten times more on research in nuclear energy than in the chemical, metal, petroleum, food, textile, paper and non-metal industries combined, which in 1958 contributed 22·5 per cent of its national income. This should be considered in the light of the statement of a Nuclear Energy Commission spokesman that Yugoslavia will need nuclear power at the earliest 20–25 years from now[9].

"Science is the motor of social progress", said one of the slogans at the fifth Congress of the Socialist League of Yugoslavia, its mass political organization, in May 1960. The logic which neglects the development of a sound research policy results in the development of all parts of the vehicle of social progress except one: its motor. From all that has been said it emerges that the usual economic indicators are necessary but not sufficient as a measure of economic development. Any measurement of economic development to be adequate must include indicators about this motor, that is, about the scientific effort, the scientific potential and its scientific and social productivity.

[1] Melentive Popovich (president of the newly formed Federal Research Council), "The Social Aspects of Scientific Research" (*Socijolizon*, No. 1, 1960).
[2] Annual Report of the Advisory Council on Scientific Policy 1956–57 (H.M.S.O., London).
[3] "La Matière Grise et L'Europe" (Centre de Recherche Européenes, Lausanne, 1960).
[4] "Comparisons of the U.S. and Soviet Economies", Part 2 (G.P.O., Washington, 1959).
[5] Lewis, W. A., "The Theory of Economic Growth", 175 (Allen and Unwin, Ltd., 1955).
[6] "The Scientific Revolution", by Elbers, G., and Duncan, P., 97 (Public Affairs Press, Washington, D.C., 1959).
[7] Ewell, R., *Chem. and Eng. News* (July 18, 1955).
[8] "Physics in Indian Universities", *Nature*, **181**, 23 (1958).
[9] *Avdo Humo*, '*Borba*' (Dec. 28, 1959).

Principal Sources used in Tables

(1) Statisticki Godisnjak 1959, Savezni Savet za Statistiku, Beograd.
(2) Jugoslovenski Pregled 1957, 1958.
(3) Izvestaj Savezne Industrijske Komore za 1957, 1958, Beograd.
(4) Statistical Abstract of the United States (G.P.O., Washington, 1959).
(5) Annual Abstract of Statistics, No. 96 (H.M.S.O., London, 1959).
(6) Colonial Research 1958–59 (H.M.S.O., London).
(7) Annual Report of the Advisory Council on Scientific Policy, 1956–57 (H.M.S.O., London).
(8) S.S.S.R. v Cifrah, Statisticeski Zbornik, Centralnoe Statisticeskoe Upravlenie pri Sovete Ministrov S.S.S.R. (Moskva, 1958).
(9) Scientific Research in Great Britain (G.P.O., Washington, 1960).

MEASURING THE SIZE OF ISOLATED CELLS

By Dr. SAMUEL S. EPSTEIN and JACQUELINE B. WEISS

Hospital for Sick Children, Great Ormond Street, London, W.C.1

THE accurate sizing of individual cells is a problem which has interested microscopists since the seventeenth century. One of the earliest recorded attempts at measuring the size of cells was made by Leeuwenhoek[1] in 1684. He selected grains of sand of similar size, arranged them along graduated lines and determined the number of grains to the inch. He then attempted to size red blood cells by relating their diameters to a grain of such sand. An equally ingenious approach was that of Jurin[2], who in 1718 twisted hair finely around a pin and measured microscopically the length of a coil and the number of component twists, thus obtaining the diameter of the hair. He then counted the number of red cells which equalled the diameter of a segment of hair.

With the progress of optical science and microscope design, projected cell images were measured by means of an ocular prism attachment (camera lucida). No real degree of precision, however, was reached until 1910 when Price-Jones[3] described his classical method for determining variations in the diameters of red blood corpuscles. He projected the images of microscopic fields of stained blood films directly on to paper in a system of known magnification. Individual cells were outlined in pencil, measured with a millimetre scale and their diameters expressed in μ. The average diameters of successive groups of 100 cells were found to be relatively constant. This procedure was afterwards refined when Price-Jones[4], applying the statistical concept of Yule[5], plotted size distribution curves of groups of 500 red blood corpuscles. He also suggested methods for the measurement of non-circular cells, based on the assumption that the average of their greater and smaller axes approximated to the circular diameter.

In 1924, Pijper[6] demonstrated that red blood cells spread in a monolayer on a glass slide would function as a diffraction grating—the translucent interspaces allowing passage of unaltered light. Diffraction would thus occur at the edge of each cell. This same observation had, in fact, been made a century previously by Young[7], who devised an 'eriometer' to measure size of wool fibres and later adapted this to red blood cells. A source of illumination, viewed through such a slide as Pijper described, appeared surrounded by a series of concentric halo spectra, the size of the halo being inversely proportional to the size of the cell. This method is of limited value when there is much anisocytosis, as it determines the modal rather than the arithmetic mean. Furthermore, it is strictly applicable only to cells which are both circular and translucent.

Measuring the approximate size of bacteria was performed in 1926 by Wilson[8], who related opacities to cell counts of suspensions of organisms. Earlier, Brown[9] had related the dried weight of organisms to their opacity in suspension. At this time bacteriologists on the whole were not interested in determining the size of bacteria—accepting the doctrine of Koch that cell forms are invariably constant. However, in 1928, Henrici[10], in a monograph on problems of morphological variations of bacteria, described in detail several methods for measuring the size of micro-organisms. For rod-shaped organisms he applied the type of projection method described by Price-Jones, and expressed cell size as a function of length. He also made size-distribution studies at different phases of growth, in this respect preceding Price-Jones's concept that determinations of average cell size alone were of limited value. With curved

organisms, such as *Vibrio cholera*, he re-photographed the pencilled cell images as composite photographs, arranging the organisms in such a way that the centres and long axis of each separate cell coincided as nearly as possible on the plate. He measured cell area with a planimeter and length with dividers and derived an area/length index distribution curve for each stage of growth. For very small organisms he devised a method designed to overcome the difficulties of projection at high magnifications: projecting the cell images on to panchromatic films at a magnification of 3,000 times and reprojecting these photomicrographs at a magnification of 7–10 times. The projected images were traced on to cards and their area and length measured. Henrici found that by counting a sufficient but unspecified number of cells, the error due to fuzziness at the edge of the projected images could be compensated. He did this by tracing through the centre of the "zone of unsharpness", the chances being as great for "going inside the middle of this zone as outside of it". More recently an original technique, based on comparative weights of paper cut-outs of projected cell images, has been applied to a microbiological system[11].

Ocular Graticules

In recent years measuring the size of particles has attracted the attention of physicists and in the course of the past decade two distinct approaches to this problem have been evolved: the visual and the automatic. Strictly visual methods of measuring the size of particles applicable to cells involve the use of eye-piece graticules. These constitute a modification of the micrometer described more than a century previously by Kater[12], whereby a scale seen with the left eye was superimposed on cell images seen with the right eye. The more recent methods consist essentially of graticules with rectangular grids defining the counting area and a series of reference circles in the grid by which images are visually matched[13,14]. Other methods of reference include graticules with vertical lines of known separation[15], and gauges such as the filocytometer. Statistically designed techniques employing particle profile test strips have been used to assess the accuracy of graticule methods and minimize observer bias[16].

Spot Scanning

In general, automatic devices have depended on the use of television techniques and the photo-electric spot scanning of a specimen, either directly from a microscope preparation or from a photograph which can be taken from living material[17,18]. These methods are capable of providing rapid information and enable the analysis of numerous replicates. Several principles of spot scanning have been applied; these include double scanning, which compares counts obtained by scanning at different track widths, and intercept length scanning, whereby the number and length of intercepts of scanning lines across particles are measured and area and perimeter of the particle deduced. The guard spot method is a refinement of the intercept method and involves the use of two scanning spots, one controlling counting of the other. The absence of the control signal indicates that the lower or upper edge of a scanned particle has been reached. Thus a count of one is registered for each particle. Information from such a scanning analyser can be obtained in three forms: total count, mean area and approximate size distribution of particles or cells.

Certain errors may be introduced in both counting and estimating size by the aggregation of cells and, furthermore, irregularly shaped cells may be counted more than once due to re-entry of the counting spot. Information in the case of these cells may best be derived from their mean area in a given field by the integration of total cell area and count. Size distribution analyses are not easily performed. With circular cells, size is generally expressed in terms of diameter, and measuring size can be performed by counting only cells the diameters of which exceed a selected length. A distribution analysis of the complete field can therefore be obtained by counting at consecutive size increments—the value of the increments being determined by the field size. Where small size increments, such as those for red blood cells, are required, distribution curves cannot be obtained at a useful magnification on conventional machines. In general, the minimum measurable increment is of the order of 1·5–2μ in a field of 300μ^2.

The flying-spot particle resolver, which uses an electronic memory device to simulate the double scanning spot, has been used for the determination of the mean area of *Euglena gracilis* grown at various concentrations of vitamin B_{12} (ref. 19).

Double-Image Microscopy

A semi-automatic visual method of determining the size of a cell—a double-image microscope micrometer—has recently been described[20,21]. This consists essentially of a mirror mounted on the diaphragm of a loudspeaker-type transducer, which is introduced between objective and eye-piece in a simple microscope system. The transducer is fed with alternating current, and the light source is arranged to flash when the vibrating mirror is at extreme positions. As a result of persistence of vision, two stationary images of each particle are seen. Image separation, in a vertical direction, depends on the amplitude of current and can be varied by means of a potentiometer. The diameter of a circular cell can thus be recorded on a calibrated ammeter after image separation has been adjusted so that the two images just touch. With irregular particles the microscope stage is rotated so that any chosen chord of the particle may be measured in the same manner. The reproducibility of this method for measuring circles is better than 1 per cent at 10μ and 3 per cent at 1μ. The instrument can be fitted with an electromagnetic device[22] for size distribution analyses. A more tedious modification involving the same principle in which, however, the image is split by shearing with two prism blocks arranged as an interferometer has also been described[23].

Cell Conductivity

The methods so far described are only capable of evaluating optical cross-sections of cells. A machine has, however, been devised (Coulter Electronics, Chicago) for the automatic measurement of cell volume[24,25]. This method depends on differences in resistance between cells and the fluid medium in which they are suspended. The cell suspension is forced through a small aperture of appropriate width, which has an immersed electrode on either side. Each cell, as it passes through the aperture, causes a change in resistance between the electrodes. A

voltage pulse of short duration is thus produced which has a magnitude proportional to the size of the particle and which is essentially proportional to particle volume. The voltage pulses are amplified, fed to a threshold circuit with an adjustable threshold-level and counted. By counting at successive threshold increments, size distribution curves can be easily and accurately obtained. Corrections are automatically made for co-incident passage of more than one particle through the aperture, and the large number of particles counted minimizes error. Calibration is performed by using standard particles of known size. The accuracy of this method as applied to measuring the size of bacteria has been shown to be of the order of 2 per cent of the diameter for 1μ spheres[26]. It will be obvious that information obtained from a machine of this nature is of greater potential value to biologists than more conventional methods merely measuring some planar function.

[1] Leeuwenhoek, A. van, *Phil. Trans. Roy. Soc.*, **1673**, 789 (1684).
[2] Jurin, J., *Phil. Trans. Roy. Soc.*, **30**, 762 (1718).
[3] Price-Jones, C., *Brit. Med. J.*, ii, 1418 (1910).
[4] Price-Jones, C., "Red Blood Cell Diameters" (Oxford Medical Publications, London, 1933).
[5] Yule, U., "An Introduction to the Theory of Statistics", fifth ed. (London, 1919).
[6] Pijper, A., *Lancet*, ii, 367 (1924).
[7] Young, T., "Introduction to Medical Literature", 578 (1823).
[8] Wilson, G. S., *J. Hyg.* (Lond.), **25** (2), 150 (1926).
[9] Brown, H. C., *Indian J. Med. Res.*, **1**, 711 (1914).
[10] Henrici, A. T., "Morphologic Variation and the Rate of Growth of Bacteria", **1** (Baillière, Tindall and Cox, London, 1928).
[11] Epstein, S. S., and Weiss, J. B., *Biochem. J.*, **75**, 247 (1960).
[12] Kater, H., *Phil. Trans. Roy. Soc.*, 419 (1814).
[13] Patterson, H. S., and Cawood, W., *Trans. Faraday Soc.*, **32**, 1084 (1936).
[14] Fairs, G. L., *Chem. and Indust.*, **62**, 374 (1943).
[15] Hamilton, R. J., Holdsworth, J. F., and Walton, W. H., *Brit. J. App. Phys.*, Supp., No. 3 (1954).
[16] Watson H. H., and Mulford, D. F., *Brit. J. App. Phys.*, Supp. No. 3, (1954).
[17] Hawksley, P. G. W., Blackett, J. H., Meyer, E. W., and Fitzsimmons, A. E., *Brit. J. App. Phys.*, Supp. No. 3 (1954).
[18] Causley, D., and Young, J. Z., *Research*, **8**, 430 (1955).
[19] Epstein, S. S., Weiss, J. B., Causley, D., and Bush, P. (unpublished work).
[20] Timbrell, V., *Nature*, **170**, 318 (1952).
[21] Timbrell, V., Physical Society Exhibition Handbook (London, 1958 and 1959).
[22] Phys. Soc. Exhibition (Abstracts), *Lab. Prac.*, **8** (1), 33 (1959).
[23] Dyson, J., *Nature*, **184**, 1561 (1959).
[24] Brecher, G., Schneiderman, M., and Williams, G. Z., *Amer. J. Clin. Path.*, **26** (12), 1439 (1956).
[25] Berg, R. H., Symposium on Particle Size Measurement. American Society for Testing Materials. Special Tech. Pub. No. 234.
[26] Kubitschek, H. E., *Nature*, **182**, 234 (1958).

NEWS and VIEWS

Electrical Engineering in the Imperial College of Science and Technology

SIR WILLIS JACKSON, director of research and education with Metropolitan-Vickers Electrical Co., Ltd., now the Associated Electrical Industries, Ltd., and president of the Institution of Electrical Engineers, has been appointed to the chair of electrical engineering at the Imperial College of Science and Technology, London. He will take up this post in October 1961, succeeding Prof. Arnold Tustin, who has been responsible for the central planning of the new building for the Department, and who has for some time wished to relinquish the post of head of the Department. Prof. Tustin will continue to direct the work of the Department in the field of heavy electrical engineering. Other leading members of the Department are Prof. Dennis Gabor (applied electron physics) and Prof. Colin Cherry (telecommunications).

The new appointment exemplifies the very close links which now exist between industry and the Imperial College at the highest level. Sir Willis Jackson resigned his chair at the College some seven years ago to go to Metropolitan-Vickers (see *Nature*, 171, 242; 1953). From this position he has exercised great influence both within the electrical industry and in the field of technological education in general. Now he is to return to his old College and his old Department. It is of the highest significance that one of the most distinguished technologists in Britain should be re-entering the academic ranks in a key post.

Royal Society Visiting Professorship: Prof. A. Schlüter

THE Royal Society has instituted a visiting professorship so that oversea scientists of high distinction may be invited to the United Kingdom for a period of an academic year, or at least six months, to enable them to carry out research. The first holder of the appointment will be Prof. Arnulf Schlüter, professor af theoretical physics in the University of Munich, ond also of the Max-Planck-Institut für Physik und Astrophysik, Munich. He will take up the appointment on March 1, 1961, and work in the Department of Applied Mathematics and Theoretical Physics at Cambridge on problems in theoretical astrophysics and plasma physics. Prof. Schlüter, although still a young man, has achieved international distinction for his work. He was among the first to perceive the importance of magnetic fields in interstellar gas clouds, and has made many contributions to cosmical electrodynamics. He has clarified the nature of conductivity in ionized gases, and advanced the knowledge of the conditions for equilibrium and stability of plasmas. More recently he has investigated the conditions for thermonuclear reactions.

Sociological Studies at the University of Sheffield: Prof. R. K. Kelsall

MR. R. K. KELSALL, at present head of the Department of Social Studies at Sheffield, has been appointed to a newly created chair of sociological studies. Mr. Kelsall was educated in the University of Glasgow and graduated M.A. with honours in political economy and history. He was awarded a Clarke postgraduate scholarship and a Leverhulme research grant, and also the Gladstone Prize. In 1933 he was appointed lecturer in the Economics and Commerce Department of University College, Hull, and was made head of this Department in 1939. In 1944 he took up an appointment as research officer in charge of the Ministry of Town and Country Planning's regional research unit for Birmingham and the West Midlands, and held this appointment until 1950, when he was appointed senior research officer in charge of the Nuffield Sociological Research Unit at the London School of Economics. He was appointed head of the School of Social Studies in the University of Sheffield in 1957, the post he now holds. Mr. Kelsall has had wide experience of many different

kinds of social surveys, and has published many articles and several books on the results of his work.

Institution of the Rubber Industry : Awards

Dr. Erich Konrad, formerly director of the Leverkusen Laboratories, Farbenfabriken Bayer, has been awarded the Colwyn Medal of the Institution of the Rubber Industry, the highest honour of the Institution, for conspicuous services to the rubber industry especially in the field of synthetic rubber development. As an assistant in the Chemical Institute of the University of Freiburg, Dr. Konrad entered the field of high-polymer chemistry. With his appointment in 1927 to Bayer at Leverkusen, his work received a decisive turn towards the chemistry and technology of rubber. His work on rubber synthesis reached the point of practical application in the setting up of synthetic rubber plants as early as 1936, and was recognized by the award of the Gold Medal by the Committee of the International Exhibition in Paris, 1937. The work of Dr. Konrad is one of the foundation stones on which the present-day synthetic rubber industry is built, and his rich experience in this field has given a decisive impetus to the development of new elastomers and new types of foamed materials.

The Hancock Medal of the Institution for 1960 has been awarded to Mr. C. B. Copeman, chairman of Maclaren and Sons, Ltd., publishers, for outstanding services to the Institution and the rubber industry.

Selby Fellowship: 1960 Award

Dr. W. Deuchars, of the United Kingdom Atomic Energy Authority, has been awarded the Selby Fellowship for 1960. The award was established last year (see *Nature*, **184**, 684 ; 1959) "to recognize that, whereas there are numerous scholarships that enable Australian graduates to proceed overseas for research experience, there is now a need for measures to bring young graduates from British and other overseas universities for postdoctoral work in Australian laboratories". The award, which is being administered by the Australian Academy of Science, Canberra, is normally for one year's work in an Australian university or research institute in any branch of physical or biological science. It carries a stipend of £A.1,500, and up to £A.500 of the holder's travel costs are met. Dr. W. Deuchars will go to Canberra and will work with Prof. E. W. Titterton at the Australian National University, Canberra. Applications for the next award close on August 31.

U.K. Commonwealth Scholarship Commission

Following the setting up in the United Kingdom of the Commonwealth Scholarship Commission early this year under an Act of Parliament (see also this issue of *Nature*, p. 441), it has now been decided to award about 220 scholarships tenable in the United Kingdom from October onwards. The majority of these scholarships will be at the postgraduate-level and for two years, covering the cost of fares, tuition fees and living expenses while the holder of the scholarship is in the United Kingdom. The Commonwealth Scholarship Commission has now issued its first list of recipients for the award. This list of successful candidates covers nine Commonwealth countries and includes 66 awards, of which 44 are for scientific subjects. The distribution of these first scholarships is as follows: Canada, 18 (9 scientific); Australia, 16 (10 scientific); New Zealand, 10 (8 scientific); Ceylon, 6 (5 scientific); Hong Kong, 8 (5 scientific); Kenya, 3 (all scientific); Singapore, 3 (2 scientific); Tanganyika, 1 scientific; and Uganda, 1 scientific.

Road Research

Delegates from thirteen member and associated countries of the Organization for European Economic Co-operation have recommended that an international body should be set up to foster road-safety research. It is suggested that the international body should be responsible for co-ordinating the research effort of the various countries concerned; to foster the interchange of road-research information; and to recommend new researches on problems the solution of which requires, or would profit from, international co-operation. It was also recommended that each country should set up a national committee for road-safety research which would, in addition, provide a link with the proposed international body.

Integration of the Cape and Royal Greenwich Observatories

The merging has been announced of the Cape Observatory with the Royal Greenwich Observatory under the Astronomer Royal. The Astronomer Royal and H.M. Astronomer at the Cape of Good Hope have been, and will continue to be, responsible to the Admiralty through the Hydrographer of the Navy. The Cape Observatory fulfils, in the southern hemisphere, much the same functions as those performed in the northern hemisphere by the Royal Greenwich Observatory the work of which it supplements, and there will be many advantages to be gained from the integration of the two Observatories.

Nature Conservation in Wales

The Nature Conservancy has recently announced developments in its work in Wales, including the establishment of a new Nature Reserve at Cwm Glas, Crafnant, which, lying at the head of an upland valley, runs south-west for a distance of four miles from Trefriw in the Conway Valley. The Reserve covers 38 acres of glacially over-steepened slopes, broken by rock outcrops, and culminating in the summit of Moel Wen. It lies on basic volcanic rock and has a rich flora, including a number of arctic–alpine species, which are here growing at a relatively low altitude. There is a remnant ash-wood with a rich ground flora, and while the predominant tree is ash there are, in addition, many exceptionally large hawthorns. Together with plants typical of lowland woods and fertile soils the wood contains rock stonecrop, orpine and hart's-tongue fern, which are more particularly characteristic of such shaded, rocky places in western Britain.

Further to the establishment by the Nature Conservancy in 1955 of the Newborough Warren Ynys Llanddwyn Nature Reserve, Anglesey, and additions in 1956 and 1959, the Conservancy has now purchased another 78 acres. The Reserve now covers 1,470 acres and has a coast line of 10–11 miles. The area is of great ecological and physiographical interest, as the boundary between mobile and fixed sand and the gradation between open and closed plant communities pass right through it. Extensions are also announced to the Coed Rheidol Nature Reserve, near Devil's Bridge in Cardiganshire, and the Reserve now covers an area of 89 acres. Coed Rheidol is an interesting example of a moist, mossy sessile oak wood with a rich associated flora and fauna which

have developed under conditions of high humidity and heavy rainfall.

British Poultry Science

When journals are being born at the rate of about two a day, the need for each new-comer must be scrutinized carefully. *British Poultry Science*, which has just been issued, is intended to be an international journal for the publication of original researches on the fowl, and for review articles (1, No. 1; April 1960. Pp. 72+xvi. Initially two numbers annually, published in April and October. Annual subscription, 30*s.*; U.S.A. and Canada, 5 dollars. Single issues, 17*s.* net; U.S.A. and Canada, 2.75 dollars net. Edinburgh and London: Oliver and Boyd, Ltd., 1960). The contents of the first number give no indication of how it is to differ from, or improve on, the established journals which already cover this field, and, indeed, some of its contents have already been published in part elsewhere. Its further aim of bringing within its covers all kinds of scientific work on the fowl is also open to question, if only because research workers prefer to publish by discipline rather than by organism (and libraries also choose to purchase on this basis). The fowl is perhaps unique among animals in already having journals devoted to it; but it is not clear that they have stimulated fundamental work on the biology of the fowl. It seems more likely that this stimulus will come from the rapidly increasing technical requirements of the poultry industry, which, in many aspects, have already outgrown their scientific base. If this new journal is to prosper, its policy will have to be more clearly defined, particularly with respect to its emphasis on pure and applied science, and towards its anticipated lay readership.

Local Health Service

Six pilot studies into local health carried out under the direction of governments throughout the world are discussed in the first part of a report called "Local Health Service", by the World Health Organization (Report Series, No. 194. Pp. 49. Geneva: World Health Organization; London: H.M. Stationery Office, 1960. 2 Swiss francs; 3*s.* 6*d.*; 0.60 dollars). The Expert Committee on Public Health Administration in this, its third report, reaches the conclusion that the methods used are generally sound, and that, in the development of health services locally, such studies should become a routine procedure, not only as a means of assessing what services exist but also as a preliminary to the setting up of new services. The Committee discusses some of the factors affecting local health services: the need for decentralization of health services and for an efficient local administration; the various methods of organizing community effort in public health work; the importance of a closer alliance between general medical practice and local health service, and the consequent need for inculcating a proper approach to public health in the undergraduate medical curriculum; and the problems of urbanization arising from the great influx of people into the towns in response to industrial demand.

Unesco Fellowships for Electronic Computing Research

The United Nations Educational, Scientific and Cultural Organization is offering six fellowships to be shared among member States to enable highly qualified specialists to undertake research in the use of electronic computers for the purpose of mechanical translation, the theory of switching or the use of computers for the reduction of geophysical data. The fellowships will normally be for six months and will carry a travel grant and a monthly allowance varying according to the country of study. Further information can be obtained from the United Kingdom National Commission for Unesco, Ministry of Education, Curzon Street, London, W.1.

University News: Belfast

Among recent appointments to lectureships are the following: Dr. N. T. Dunwoody (engineering mathematics) and Mr. R. G. A. Stretch (psychology).

Birmingham

Dr. I. E. Bush has been appointed to the Bowman chair of physiology and to the directorship of the Department of Physiology from October 1. Dr. Bush has been a member of the external staff of the Medical Research Council since 1958, and is also a Senior Research Fellow at New College, Oxford.

The title of professor of physiological chemistry has been conferred on Dr. W. V. Thorpe, who is at present reader in chemical physiology, as from October 1.

The following appointments are also announced. *Lectureships:* Dr. J. D. Dowell, Dr. P. Swinbank and C. P. van Zyl (physics); Dr. J. M. Webber (chemistry); K. Foster (mechanical engineering); Dr. G. W. Rowe (industrial metallurgy); Dr. V. J. Emery (mathematical physics); Dr. E. F. Stack-Forsyth (electrical engineering); R. N. Morris (econometrics and social statistics). *Research Fellowships:* Dr. T. F. Tuan (mathematical physics); Dr. N. Pessall and B. Cockayne (physical metallurgy); D. J. White to be Kenward Memorial Fellow (engineering production); H. R. Shaylor to be Staff Fellow in nuclear physics in the Department of Physics.

Bristol

Prof. T. K. Ewer, at present professor of animal husbandry in the University of Queensland, has been appointed to the chair of animal husbandry. The following appointments are also announced. *Lectureships:* Dr. P. C. Caldwell (biochemistry within the Department of Zoology); A. J. B. Cruickshank (physical chemistry); Dr. I. O. Sutherland (organic chemistry). *Research Fellowship:* Dr. P. H. Fowler (physics).

Edinburgh

The following appointments have been announced: *Readerships*, Dr. J. P. Duguid (bacteriology) and Dr. C. A. Beevers (chemistry); *Lectureships*, J. R. Small (accounting and business methods), Dr. C. G. Thomson (clinical chemistry), Dr. D. J. McAuliffe (ophthalmology), and Dr. F. M. Martin (public health and social medicine).

Leeds

Dr. F. Hepburn has been appointed lecturer in medical physics.

Among the grants in aid of research which have recently been announced are: £5,000 to the Department of Physics from the Department of Scientific and Industrial Research; £2,100 to the

Department of Civil Engineering from the Cement and Concrete Association; 7,000 dollars to the Department of Biomolecular Structure from the Muscular Dystrophy Association of America.

London

Dr. C. B. B. Downman has been appointed to the Sophia Jex-Blake chair of physiology at the Royal Free Hospital School of Medicine; Dr. I. Doniach to the chair of morbid anatomy tenable at the London Hospital Medical School; and Dr. J. Hamilton to the second chair of physics tenable at University College. Among the appointments to readerships are: Mr. A. J. Buller (physiology), tenable at King's College; Mr. J. C. de Courcy Henderson (reinforced concrete structures), tenable at the Imperial College of Science and Technology. Titles of "professor in the University of London" have been conferred on Dr. H. Elliot (physics), in respect of his post at the Imperial College of Science and Technology, and on Dr. W. J. Hickinbottom (organic chemistry), in respect of his post at Queen Mary College. Titles of professor emeritus have been conferred on Prof. T. J. Bosworth (veterinary pathology), Prof. E. S. Pearson (statistics), Prof. Dorothy S. Russell (morbid anatomy), Prof. W. Smith (bacteriology), and Prof. E. E. Turner (chemistry).

Prof. E. T. C. Spooner, University professor of bacteriology and immunology, London School of Hygiene and Tropical Medicine, has been appointed dean of the School in succession to the late Sir James Kilpatrick.

Sheffield

The following appointments to lectureships have been announced: Mr. F. W. G. Warren (applied mathematics); Dr. D. N. Jones (chemistry); Dr. R. N. Dixon (chemistry); and Dr. J. M. West (metallurgy).

"Roughness of the Moon as a Radar Reflector"

The portion of this issue of *Nature* including the communication with the above title (p. 490) was printed before the mistake referred to below was noticed. Dr. B. H. Briggs writes: "Owing to an unfortunate error, the dotted curve in the graph is approximately $\exp(-20\theta)$ and not $\exp(-10\theta)$ as stated. The detailed agreement between the optical observations and the radar results of Hughes is therefore not as close as was originally thought, though it remains true that both methods indicate a mean slope of the order of 3°. I am indebted to Dr. Hughes for pointing out the above error".

Announcements

The Medical Research Council's Neuropsychiatric Research Unit, under the direction of Dr. D. Richter, has been transferred from the Whitchurch Hospital, Cardiff, to the Council's Laboratories at Carshalton, Surrey.

Dr. R. L. Smith-Rose, who is retiring from the post of director of the Radio Research Station of the Department of Scientific and Industrial Research (*Nature*, 185, 353; 1960), has been appointed chairman of the Post Office Frequency Advisory Committee in succession to Sir Lawrence Bragg.

Prof. F. D. Richardson, professor of metallurgy in the Imperial College of Science and Technology, London, will deliver the fourth Robert Horne Memorial Lecture of the Society of Chemical Industry in the Chemistry Department, University of Bristol, on September 29, at 6.30 p.m. He will speak on "The Extraction of Metals and the Chemistry of Metals". The Lecture is open to the public.

An international colloquium is to be held at the University of Grenoble on "The Physics of Electrostatic Forces and Their Applications" during September 27–October 1. The Colloquium is organized by Le Centre National de la Recherche Scientifique. Further information can be obtained from Prof. Noël Felici, Faculté des Sciences, Université de Grenoble, Grenoble.

The European Association for Potato Research has announced its intention to organize a series of triennial conferences to review the position of potato research. The first of these conferences is to be held at Brunswick during September 12–17. Further information can be obtained from Tagungsbüro der EAPR, Institut für Pflanzenbau und Saatguterzeugung, Bundesallee 50, Brunswick.

The Plastics and Polymer Group of the Society of Chemical Industry has arranged a three-day symposium on "High-temperature Resistance and Thermal Degradation of Polymers", to be held during September 21–23 at the William Beveridge Hall, Senate House, University of London. Further information can be obtained from the Convenor, Plastics and Polymer Symposium Sub-Committee, 14 Belgrave Square, London, S.W.1.

The Institution of Gas Engineers and the Corrosion Group (Birmingham and Midlands Section) of the Society of Chemical Industry are organizing a joint symposium on "The Protection of Gas Plant and Equipment from Corrosion", at the College of Advanced Technology, Birmingham, during September 22–23. Further information can be obtained from the Symposium Secretary, Department of Chemistry, College of Advanced Technology, Costa Green, Birmingham, 4.

The Chemical Society of London has announced that it will consider a number of applications for the assistance of research in any branch of chemistry. About £700 per annum is available for this purpose. Applications should be made to the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1, not later than November 15.

The Commonwealth Scientific and Industrial Research Organization (Australia) has issued a List of Publications to December 31, 1959, including both those of the Organization itself and of its predecessors (Pp. 45. Melbourne: Commonwealth Scientific and Industrial Research Organization, 1960). The publications are arranged under handbooks and monographs: journals; bulletins; pamphlets; circulars; land research series; soil publications; leaflets; semi-technical periodicals; divisional publications; and miscellaneous publications. There is also a subject index.

Erratum. In the communication entitled "Two Types of Catalase-like Activity in the Lactic Acid Bacteria", by R. Whittenbury, in *Nature* of July 30, p. 433, there is an error in Table 1. The number of catalase-positive organisms recorded for *L. cellobiosus* and *L. viridescens* are 2 and 0, respectively; they should read 0 and 2.

THE JOHN INNES INSTITUTE

THE fiftieth anniversary of the John Innes Horticultural Institution was celebrated on July 8. The occasion served not only to recall the past achievements of the Institution, but also to announce some major new developments. These included a change in the title of the Institution, an extension of the scope of its activities and the opening of a new laboratory building.

Cell Biology and the construction of a large building to house it represent a new departure. The Cell Biology Laboratory (Fig. 1), shown in the photograph, was erected by the Trustees of the John Innes Charity and is being supported by the Agricultural Research Council. When fully equipped and staffed, the new building will provide excellent research facilities for some twenty-five scientists.

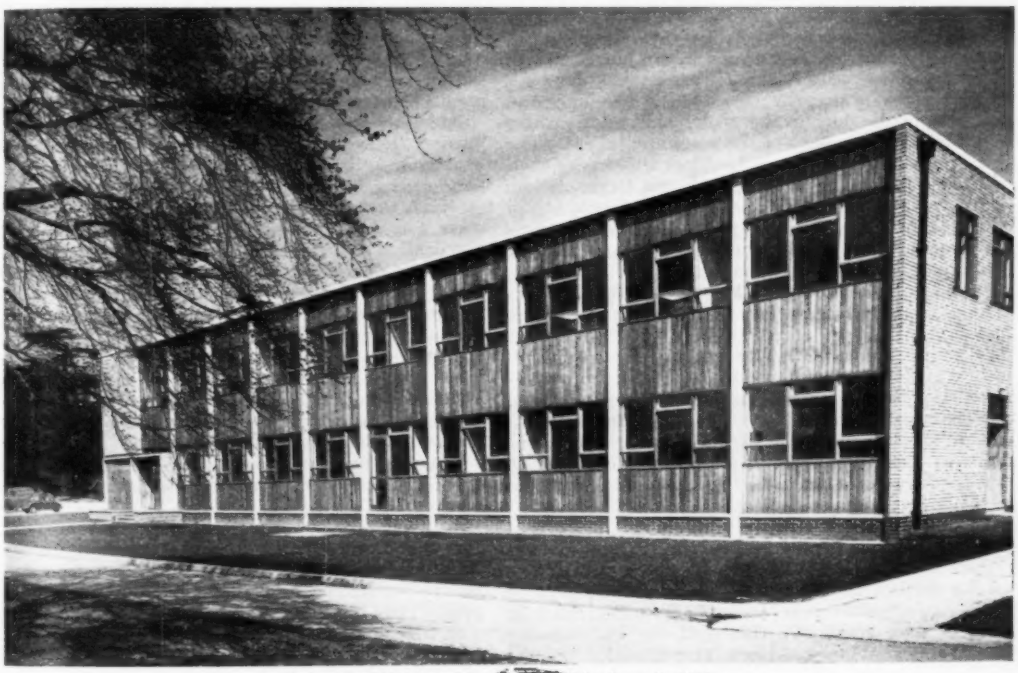


Fig. 1. The Cell Biology Laboratory, John Innes Institute

The John Innes Horticultural Institution was founded under the will of John Innes, of Merton, and began its life in that London suburb in 1910. William Bateson was the first director, and it was he who chose genetics and cytology as subjects for investigation; work which reached its climax just before the Second World War, when C. D. Darlington had published "Recent Advances in Cytology" (1932) and "The Evolution of Genetic Systems" (1939). Some of the other books published by members of the staff during this pre-war period were: "Recent Advances in Plant Genetics" (1932) by F. W. Sansome and J. Philp, "The Genetics of Garden Plants" (1934) by M. B. Crane and W. J. C. Lawrence, and "Practical Plant Breeding" (1937) by W. J. C. Lawrence. With the resumption of full-scale research activities after the War, there came K. Mather's work on quantitative variation and his book "Biometrical Genetics" (1949).

While the tradition in genetical studies is being maintained with the recent appointment of Dr. J. R. S. Fincham to take charge of the Department of Genetics, the establishment of a Department of

The Department of Cell Biology has no categorical commitment, and its members will be free to pursue their own research interests within the very wide framework implied by the term 'cell biology'. One of the features of the Department is the fact that facilities are available for work on both animal and plant material, and a new animal house is being built to meet the demands imposed by the work on animal cells. It is hoped that this fusion of disciplines and the wide variety of techniques which it involves will provide unique opportunities for the intimate exchange of ideas and experimental skills. The new Department thus represents the fulfilment of hopes originally expressed by Bateson himself, who made it a condition of his appointment as the first director that he should be allowed to carry out studies on animals as well as plants. Dr. Henry Harris, of the Sir William Dunn School of Pathology, Oxford, has been appointed head of the new laboratory.

The original name of the Institution was felt to be too restrictive to embrace the activities which are being undertaken, and the title has now been changed to the 'John Innes Institute'.

K. S. DODDS

THE WORLD HEALTH ORGANIZATION

THE annual report of the Director-General of the World Health Organization for 1959 shows the wide range of the assistance given by the Organization to countries throughout the world, both directly in the form of projects adapted to particular needs, and through international technical services of the more traditional type*.

The 'project list', occupying more than half the volume, gives particulars of the projects, numbering more than 500, in which the World Health Organization has been co-operating with the Governments of some 140 countries, sometimes in conjunction with other organizations. A summary narrative for each project states its aim, the nature of the assistance and progress made during the year, and adds, where possible, an assessment of the results obtained. The list, grouped by country and subject title under each of the six regions of the World Health Organization, includes inter-country and inter-regional projects in which help is given to groups of countries working together on common problems—a type of project that appears to be increasing in importance.

In his introduction, Dr. M. G. Candau, director-general of the Organization, directs attention to the fact that in 1959 the Organization's work was carried on "against a general background of reduced tension in international affairs" and of "substantial improvement of economic conditions throughout the world, particularly in Europe"; and he finds growing evidence of the determination of world leaders to devote more of their countries' resources to help nations still in the early steps of technological and economic development to raise their standards of living.

In discussing some of the changes of emphasis in the Organization's programme, the director-general points out that communicable diseases remain one of the world's most serious health problems. For some, more knowledge is required; for others, such as malaria and smallpox, the methods are broadly known and what is wanted now is organization, trained staff and money.

Among diseases calling for increased vigilance are the treponematoses. More than 100 million people still live in low-prevalence yaws areas, in several countries there has been a disturbing recrudescence of venereal syphilis, and a growing incidence of gonorrhœa has been found in 15 out of 22 countries surveyed. Investigations are being pursued in order to ensure that the most effective assistance can be given to countries combating these problems.

With tuberculosis, recent findings which show that domiciliary chemotherapy may for most cases be as efficacious as treatment in sanatoria are of particular importance to the many countries where there is an acute shortage of sanatoria beds.

Mention is also made of the newer developments against leprosy, bilharziasis, poliomyelitis and the zoonoses, and of preparatory work with the view of eradicating smallpox.

Much preparatory work has been done during the year for the expansion and intensification of the medical research programme. Main targets and priorities, established with the guidance of the Advisory Committee on Medical Research, include the communicable diseases (with emphasis on viruses and diseases prevalent in tropical countries); for the highly industrialized countries, the chronic diseases, particularly cancer and cardiovascular troubles; nutrition, and problems of the increased risk of exposure to ionizing radiations. The 'service to research' will include standardization of nomenclature techniques and equipment, and the expansion of, the Organization's system of international reference centres.

Emphasis is also being given to the vast programme for the improvement of water supplies for communities, which is a primary objective in the attack on the enormous problems of environmental sanitation. The programme will be carried out in collaboration with departments of public works and with public administrations and financial authorities.

Annexes to the report give details of the membership of the Organization, its Executive Board and expert committees; the main heads of the budget for 1959; and particulars of the secretariat structure and composition.

* Official Records of the World Health Organization, No. 98: The Work of WHO, 1959—Annual Report of the Director-General to the World Health Assembly and to the United Nations. Pp. x+283. (Geneva: World Health Organization; London: H.M. Stationery Office, 1960.) 6 Swiss francs; 10*s.*; 2 dollars.

THE METROPOLITAN WATER BOARD

LONDON is by far the largest town in Britain taking its raw water supplies from wells in, or from rivers flowing through, a densely populated and industrialized area, and the reports of the Director of Water Examination of the Metropolitan Water Board* are an invaluable guide to the measures which have to be taken, and the research which has to be carried out, to obtain a safe potable water from these sources.

The first necessity is, of course, to control and restrict pollution of the raw water. A good example of what can be done is afforded by the River Lee; in spite of the growth of both population and industry in the catchment area between 1948 and 1958, the quality of the river water improved substantially during that period. This was due in part to the improvement and extension of the sewage works at Luton (including the provision of a final stage of treatment by rapid sand filtration or by micro-straining), and in part to the treatment of the sewage of several towns, including the new towns of Harlow and Stevenage, at a single works, discharging to the Lee below the Board's New Gauge intake.

Within the catchment area of the Thames there are three major establishments, at Harwell, Aldermaston

* Metropolitan Water Board. Thirty-Eighth Report on the Results of the Bacteriological, Chemical and Biological Examination of the London Waters for the years 1957–1958. By E. Windle Taylor. Pp. 114+4 plates. (London: Metropolitan Water Board, 1960.) 21*s.*

and Amersham, from which radioactive effluents are discharged. These liquors, in which the level of activity permitted is very low, are regularly monitored before being released—the Harwell effluent by the Atomic Energy Authority, the Ministry of Housing and Local Government, and the Metropolitan Water Board. There is no evidence, from the Board's observations, that there has ever been any activity present, at its raw water intakes, which could be attributed to discharges from the three establishments. The concentration of activity in treated water is about half that present (from fall-out) at the intakes, both in the Thames and Lee, the reduction being due to removal of suspended matter, radioactive decay during storage, and sometimes to dilution with relatively inactive well water. A large-scale experiment was made by adding 500 mc. of strontium-90 to 1·5 million gallons of water, standing in a disused filter bed; during a period of nine months the level of activity was reduced by about two-thirds (the water contained abundant algae and much rooted vegetation), but the results suggested that grossly contaminated waters would not be rendered potable in any reasonable time by storage alone.

An examination of waters from a number of wells for the presence of alkylbenzene sulphonates—the anionic surface-active agents which are the basis of powdered synthetic detergents—showed that in some they were absent, but that in others they were present in concentrations similar to those found in the Thames to which sewage effluents are discharged. It is of great interest that in a well water the presence of the surface-active material may be the only surviving evidence that the water has been polluted by sewage or sewage effluent—ammonia, coliform bacteria, and the other usually diagnostic constituents of effluents having been removed during percolation of the water through the ground. These observations were made before the use on a large scale of biologically 'softer' alkylbenzene sulphonates in detergents sold in the south of England.

Continuing its work on the relation between chemical structure and susceptibility to degradation by bacteria, a wide range of organic substances has now been examined in the Board's laboratories; from this the important conclusion is reached that because of the relative immunity of chlorine-substituted organic compounds to bacterial attack, it is unwise to chlorinate effluents containing mainly organic matter; this would include sewage effluents. Chlorination of such effluents has never been widely practised in Great Britain but appears to be common in the United States, and there has been a good deal of discussion recently on the wisdom of adopting this quite expensive method of treatment.

Among the other matters dealt with in the report are the use of automatic instruments for recording concentration of dissolved oxygen (a knowledge of which is important in taking a water supply from a thermally stratified reservoir); the presence of *Salmonella* organisms in bone meal and other fertilizers; and the persistence of fluoride in water during storage in a reservoir. Considerable advances have been made in the use of the membrane filter technique in the counting of coliform bacteria; with this method the count is available after 18 hr. as against 24 hr. with the older multiple-tube technique.

B. A. Southgate

EAST AFRICAN FISHERIES RESEARCH ORGANIZATION

To the scientist the annual report for 1959 of the East African Fisheries Research Organization can only be a somewhat depressing document*. When the Jinja Laboratory was established in 1947–48 together with the Lake Victoria Fisheries Service, there seemed to be some real prospect of keeping a developing fishery under full observation, and managing it in a scientific manner in the light of both the catch statistics collected by the Fisheries Service and the information on the biology of the fish acquired by the staff of the Laboratory. In the eleven years of its life the Laboratory has not only made good progress with the task assigned to it, but also made notable contributions to our knowledge of tropical waters. On the other hand, those responsible for government at the political level have signally failed to profit by the scientifically based advice tendered by the Research Organization. As a result, the fishery is rapidly declining in productivity owing to overfishing, precisely as it was predicted that it would in the absence of more stringent and effective control. That this small fishery should be following the same downward path as the internationally exploited sea fisheries, where control is so much more difficult to exercise, is a sad reflexion not only on man's cupidity but also on the lack of scientific understanding of so many of those we appoint to govern us. This last point is further emphasized by the fact that in the small staff at Jinja (a director, four research officers and two senior field officers) there is a vacancy for a fifth research officer which cannot at present be filled for lack of finance. Consequently, the work of the Laboratory is now restricted almost entirely to fish, and moreover the Lake Victoria Fisheries Service has been disbanded, though its duties have been, at least nominally, transferred to the Fisheries Departments of the three Territories concerned (Kenya, Tanganyika and Uganda). It is much to be hoped that means will be found to continue the fundamental observations on the hydrography and chemistry, and the algal and invertebrate populations of the Lake, on which the Laboratory has made such an excellent start.

A series of appendixes give in a convenient, concise and readable form the results of some of the work done at the Laboratory during the year. One of these contains important observations on the analysis of data based on gill-net catches, made by a member of the staff of the Fisheries Laboratory at Lowestoft. Another shows how easily and rapidly the very local populations of *Tilapia esculenta* in Lake Victoria can be over-fished down to a level at which the yield ceases to be profitable. A third gives briefly the results of an investigation, made by an entomologist, of the food of several of the species of fish other than Cichlidae which inhabit Lake Victoria. In contrast to the mainly herbivorous species of *Tilapia*, the

* East Africa High Commission. East African Fisheries Research Organization: Annual Report 1959. Pp. ii+46. (Jinja: East African Fisheries Research Organization, 1960.)

species of *Alestes*, *Synodontis afro-fischeri* and *Marcusenius grahami* eat mostly insects, whereas *Barbus altianalis* and *Synodontis victoriae* get most of their sustenance from snails. Other appendixes contain shorter notes on a variety of topics, including the growth of *Tilapia zillii* in a dam and some preliminary observations on the control by fish of snails and mosquitoes in dams.

The director, Mr. R. S. A. Beauchamp, who has recently relinquished the post he has held with distinction since he opened the Laboratory in 1948, can look back on a considerable achievement. Not only have he and his colleagues laid a firm foundation of knowledge of the hydrography, chemistry and biology of at least the parts of Lake Victoria within the reach of the Laboratory, but they have also made significant contributions, briefly described in the reports of which this is the latest, to our understanding of the factors which control the productivity of tropical waters. Moreover, the Laboratory itself now has a world-wide reputation and attracts visitors from many countries.

H. C. Gilson

U.S. MATERIALS RESEARCH AND DEVELOPMENT FOR NATIONAL SECURITY

A SPECIAL Committee on Scope and Conduct of Materials Research was appointed by Dr. D. W. Bronk, president of the National Academy of Sciences, to review the materials research needs of the United States with regard to national defence and the public welfare generally; to appraise the adequacy of the present research programmes to meet those needs; to consider the resources available; and to make recommendations. A report now issued under the title "More Effective Organization and Administration of Materials Research and Development for National Security" deals with the scope of materials research from the point of view of the overall adequacy of the present effort, but leaves for continuing review by the Materials Advisory Board of the National Academy of Sciences–National Research Council the question of scope in regard to the technical content of the programme*. The question of scope in regard to the scientific content will be dealt with in a forthcoming report of the Academy–Research Council's Committee on Perspectives in Materials Research.

The Committee found that important national security programmes, particularly in defence, nuclear energy and space-research are impeded by the inadequacy of the properties of most of the materials now available to withstand the severe temperature, pressure, radiation, corrosion and stress conditions involved and give high performance. The Committee recommends accordingly that the Government accord high priority in national security plans and programmes to the development of new and improved materials and that the relevant programmes of the agencies and departments be strengthened. The Committee recognizes that there is no simple solution, but that every level of activity needs significant strengthening. To this end it recommends greater centralization of responsibility, more support for, and more effective co-ordination of Government-sponsored materials research and development programmes; Government incentives to encourage research and development on new and improved materials; and steps to assure adequate supplies in the United States of every chemical element or material to support full production and use of new and improved materials. It also recommends improvement in the dissemination of research information and strengthening the universities in their dual role of training scientists and engineers and pursuing research. In regard to the last, the Committee endorses a recently announced programme of Government-sponsored interdisciplinary materials laboratories at several institutions of higher learning, while as regards the dissemination of information it envisages the encouragement and acceleration of publication and removal of secrecy restrictions as well as the greater support of research designed to encourage rapid exchange of technical and scientific information, including expansion and acceleration of the Critical Tables project.

* National Academy of Sciences–National Research Council. Publication No. 718: More Effective Organization and Administration of Materials Research and Development for National Security. (A Report to D. W. Bronk, President, National Academy of Sciences, by the Committee on Scope and Conduct of Materials Research.) Pp. ix+30. (Washington, D.C.: National Academy of Sciences–National Research Council, 1960.) 1 dollar.

EDUCATION AND INDUSTRY

BRITISH industry has traditionally been badly served by the universities and by the majority of schools. Until quite recently, they have encouraged very few of the ablest young people to think in terms of an industrial career.

The prejudice was not all on one side. The typical industrialist of not so long ago, while he was ready enough to concede the importance of craft training, and even of technical education, conceived rather narrowly, held that industry had certainly no responsibility for any but quite specialized courses, and that no useful purpose would be served by recruiting men on a basis of intellectual quality rather than skill.

Prof. D. G. Christopherson, in a recent issue of the *Esso Magazine* (Spring, 1960), suggests that, although these attitudes are changing, it is the attitude of industry which has changed most quickly and most completely in our time. Before the War, most professors of engineering spent their time resisting pressure from industry in the direction of making courses more specifically technical, so that the graduate would be better able to do a particular job immediately on joining the firm. To-day, the influence of industry is in the opposite direction. Professors of engineering are urged to keep courses general, to resist undue specialization, at least until

postgraduate-level, and to include as much material as possible of a completely non-technological character. Although employers are still interested in the professional side of what the university does, most place the greatest emphasis on intellectual quality rather than on technical expertise.

There are a number of reasons for this. In the first place, as the rate of scientific and technological progress quickened, the need for people to be adaptable, quick to learn, and capable of covering a wide field has increased. It is no good giving a man a complete specialized training if what he has specialized in is obsolete before he has reached the age of thirty.

Secondly, a large proportion of university graduates do not in fact do the job for which officially they were trained for more than a quite small proportion of their careers. Finally, as industrial concerns get larger and the place of industry in the national life increases in importance, the scope of the decisions to be taken by industry become even wider, reaching far beyond the boundaries of straightforward technical questions.

There is a fruitful field for active collaboration between the universities and industry. Many students already go to industry for vacation courses. It should be possible to relate what is done in industry much more closely to the academic side than had been done in the past. It might be possible for undergraduates and even more for postgraduates to do part of their 'course work' as an investigation of some industrial problem 'in the field'. The 'sandwich courses' in the colleges of advanced technology may prove to be the pioneers in this field.

But, no matter how good an understanding is achieved between education and industry, and no matter how courses are adjusted to meet contemporary needs, education cannot be thought of as a process which finishes in the early twenties. Some sabbatical period is as essential for men in industry as in the universities. Specialized postgraduate courses on technical subjects for people released from industry are becoming commoner and better supported. The universities and particularly the faculties of science and technology must be prepared to organize more of these courses.

Advanced technical work is not the most important purpose for which industry requires its own 'sabbatical years'. There is a stage at which intellectual renewal is particularly valuable, the stage when a man emerges from a relatively specialized department and begins to take managerial responsibility over a wider field; by that time, he has enough experience to be able to appreciate what the problems of management actually are, but usually scarcely any systematic knowledge of how they have been mastered.

Education in management in Great Britain lags a long way behind that in the United States; this is a matter to which the universities must give much more serious attention. By far the greatest difficulty is the recruiting of suitable staff. Management is essentially a practical subject, and the man who is good at it wants to practise and not to instruct.

A managerial or business school recruiting 'students' from a wide variety of industries would be better than one run by one undertaking, no matter how large; this end can perhaps be most directly achieved by co-operation between the great companies in founding their own institutions rather than by working through the existing university structure.

TRAINING IN RADIOLOGICAL HEALTH AND SAFETY

ON the night of October 10, 1957, the core of No. 1 reactor at the Atomic Energy Authority works at Windscale became seriously over-heated and as a consequence a fairly large amount of radioactive material escaped through the reactor stack and was deposited thinly over many square miles of north-west England. Once the alarm was given, the Health and Safety Services of the Authority went into action on their first major emergency test. Fortunately no significant harm was done to the populations of the surrounding areas, although the affair naturally received widespread publicity.

By now the 'Windscale incident' has almost passed into history, but it is interesting to find unexpected repercussions almost three years later. Following the accident, the Prime Minister set up a Committee under Sir Alexander Fleck to report, among other things, on the organization for control of health and safety in the United Kingdom Atomic Energy Authority. The report of this Committee directed attention to the serious shortage of trained radiological health and safety specialists and called for comprehensive schemes of instruction in this field as a "matter of urgent national importance". The Fleck Committee firmly placed the onus of leading the build-up of a national supply of specialists on the Atomic Energy Authority. In view of this, the Authority set up a further Committee under Sir Douglas Veale to consider what steps should be taken to provide a staff concerned with health and safety for the Authority, and for the nation as a whole, including the establishment of a national training centre*.

Although now a matter of extensive public concern, radiological health and safety are by no means a new problem. The hazards to man of ionizing radiations have been known since the early years of the century, and the distressing experiences of the early radiological workers have kept the matter well to the fore in the minds of their successors. In 1921 the first concerted effort to deal with the problem came with the publication of the first Recommendations of the British Committee for Radiological Protection. This was quickly followed by other national recommendations and by the Recommendations of the International Commission; the latter, revised from time to time, still form the basis of world-wide radiological protection measures. Until 1945, radiological safety was a matter of concern limited almost entirely to medical radiologists and a handful of physicists attached to hospitals and medical schools. The development of nuclear reactors and weapons changed the whole picture. Production and uses of ionizing radiations have increased enormously, the number of persons occupationally exposed has increased correspondingly, and we are now faced with the position

* Report of the Committee on Training in Health and Safety to the Authority Committee on Health and Safety, United Kingdom Atomic Energy Authority, February 1960. Pp. vi+95. (London: H.M. Stationery Office, 1960.) 5s. 6d. net.

that, to a greater or less degree, whole populations are at some hazard. The number of hospital physicists has increased and the atomic energy industry has recruited considerable staffs for health and safety work, but it is clear that further recruitment and the provision of specialized training are necessary if the inevitable hazards of ionizing radiations are to be kept to a minimum.

The Veale Committee estimates that in the present decade, Britain's needs will be met by recruiting and training some 500 staff at graduate level and 600 at technical level. These are modest enough figures, but they nevertheless represent a further demand on the country's already strained resources of scientific man-power. Of the graduate group, 200 are placed in Category *A*, with a requirement of good degrees in science, medicine or engineering and capacity to assume higher managerial responsibilities and play a leading part in scientific development. The recruitment of this category is likely to prove the most difficult. Establishment of a national training centre is rightly rejected by the Veale Committee and it is proposed the postgraduate training should be limited to a small number of university centres, using the normal advanced course and research studentships of the Department of Scientific and Industrial Research to support the trainees. This is probably a wise recommendation. Nevertheless, as a balanced radiological health and safety force requires primary qualifications in physics, chemistry, engineering, biology or medicine, considerable pressure will be required to overcome the blandishments of lucrative industry and professions and the temptations to do postgraduate research in the appropriate department of the young graduate's *alma mater*. A high level of altruism may be necessary if a well-qualified medical graduate is to accept the rigours of a Department of Scientific and Industrial Research studentship in an almost alien subject, in order to qualify in radiological health and safety.

The recruitment problem in the rather lower graduate category and in the technical grade, though not easy, should not prove insuperable. The Committee goes well beyond the question of recruitment and training of full-time health and safety staff. Recommendations are made on background training for groups of administrators, managers and professional workers whose duties may bring them into contact with radiations and radiation workers. Many other groups, varying from medical officers of health and general practitioners to public health inspectors, police and fire services and nurses, are likely to be increasingly involved in radiation problems, and wide dissemination of knowledge of radiation hazards and protection at a fairly elementary level becomes essential.

In some of the appendixes to the report, outlines are given of existing or proposed training curricula at levels ranging from a Ph.D. course to simple background courses. It is clear that if recruitment is satisfactory, adequate training can be made available. Eyebrows may, however, be raised in some university boards of studies at the proposal that some Ph.D. courses should be converted from the traditional British research pattern to the American form, including a high proportion of formal teaching and examinations.

Ionizing radiations have become a major and ubiquitous factor in modern life, and, as with other developments, they bring their own hazards. The vigorous implementation of the report could go a long way towards establishing public confidence that the hazards, which to many are strange and unseen, are kept within the limits which might reasonably be accepted in a rapidly developing civilized community.

J. E. Roberts

LOCALIZATION BY AUTORADIOGRAPHY AT −195° C. OF RADIOACTIVE AREAS IN RATS EXPOSED TO A HIGH FLUX OF THERMAL NEUTRONS: IMPORTANCE OF PHOSPHORUS-32 IN CONSECUTIVE INTERNAL IRRADIATION

By JEAN CHANTEUR and PIERRE PELLERIN

Institut National d'Hygiène, Service Central de Protection contre les Rayonnements, B.P. 30, Chatillon-sous-Bagneux, Seine

THE purpose of this present work was to localize the organs or areas of the body of a mammal capable of becoming the seat of a radioactivity induced by exposure to a flux of thermal neutrons. Autoradiography at the temperature of liquid nitrogen[1] seemed to us to be the simplest and speediest method of carrying out this localization by applying it to a young rat.

A preliminary calculation has enabled us to fix in 5 min. the duration during which such rats should be subjected to a flux of thermal neutrons (6×10^{12} n./cm.^{2}/sec.) which we had available in a large nuclear reactor so that we could both make an autoradiographic exposure in an acceptable time, and not reach an activity of the block that might be dangerous for the operators. (We thank the Service of Biology and the Exploitation Service *EL3* at Saclay which placed suitable irradiation means at our disposal for bringing this experiment to a successful conclusion.)

Rats weighing 25 gm. were placed alive, in pairs, in plastic irradiation cartridges, and the latter were conveyed by pneumatic tube to the irradiation holes of the reactor.

After 5-min. irradiation, the cartridges were removed from the reactor. We ascertained that the rats had been killed by the flux of neutrons, and that in the exposure conditions just described the dose-rate at 10 cm. from the cartridge containing the two rats was about 1 roentgen/hr. at the exit from the pneumatic tube.

With the usual precautions required by this dose-rate (screens, lead containers, remote control, etc.) we immediately proceeded to freeze the rats in liquid nitrogen (−195° C.), including them in the frozen mixture of water and alcohol, then counter-sinking the autoradiography plan according to the technique previously described by one of us[1].

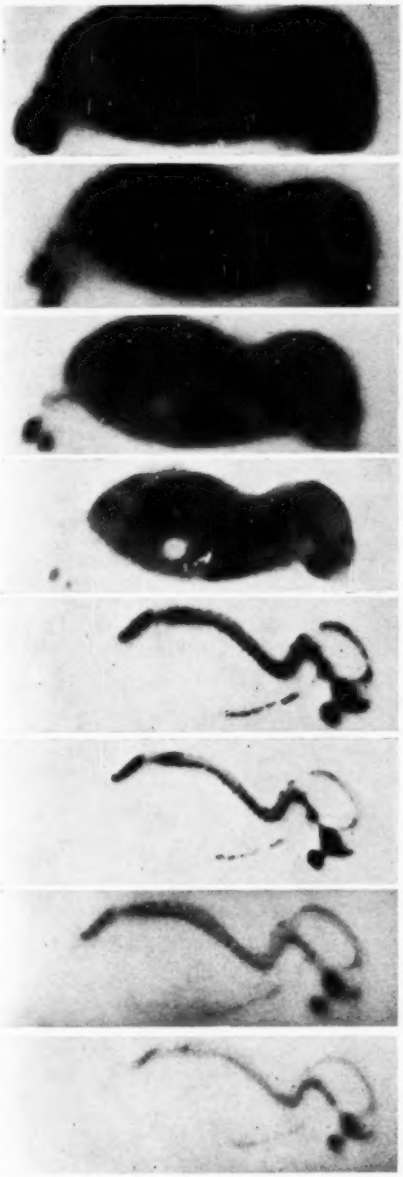


Fig. 1

In order to be able to watch the relative decreases of radioactivities induced in the various anatomical areas, we have, by a series of preliminary tests, fixed the duration of the reference autoradiograph exposure at 8 min. This reference autoradiograph was then systematically carried out after increasing times from withdrawing the rats from the reactor (successively, 1, 2, 12 and 24 hr., 5, 10, 20 and 30 days after being exposed to the flux of neutrons). We have ascertained, by interposing opaque filters, that there was no low-temperature luminescence effect[2].

Fig. 1 shows the series of reference autoradiographs, on which will be noticed that immediately after withdrawal the radioactivity induced is intense over the whole of the section surface, then progressively decreases in the course of time, at the same time that considerable localizations exist in the region of the bones and teeth.

As it was probable that saturation phenomena of the photographic emulsion could explain the general blackening of the first moments, we have, for each duration following withdrawal, systematically made other exposures, shorter, on one hand, in order to distinguish possible localizations hidden by the saturation, and on the other, longer ones to emphasize localizations tending to disappear in the course of time.

We were thus able to ascertain important bony and dental radioactive localizations from the very first moments following irradiation (Fig. 2), with an autoradiographic exposure time of 1 min. which only, however, left a general fog. After six days, this fog is much reduced on the corresponding autoradiographs (Fig. 3), which nevertheless were taken with an autoradiographic exposure time of 45 min.

As could be expected, the interpretation of activation autoradiographs thus appears to be complex, and we have been led to calculate, for the chief elements forming the system, the activities induced by exposure to the thermal neutrons previously defined, by applying the formula :

$$A = \frac{0{\cdot}6.\Phi.\sigma}{3{\cdot}7 \times 10^{10}\, M} \left\{1 - \exp(-0{\cdot}69)\frac{t}{T}\right\}$$

in which Φ is the flux of neutrons per cm.^{2} and per sec., σ the cross-section in barns, M the atomic weight of the irradiated element, t the duration of irradiation, T the half-life of the isotope formed, and A the specific activity in curies per gm. The total activity of each element was then deduced from the tables, giving the detailed chemical composition of the system.

Fig. 4 shows the decrease of some of these elements in relation to time. Autoradiographic detection can only be applied to elements possessing at the same

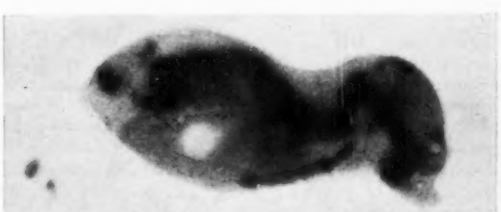


Fig. 2

Fig. 3

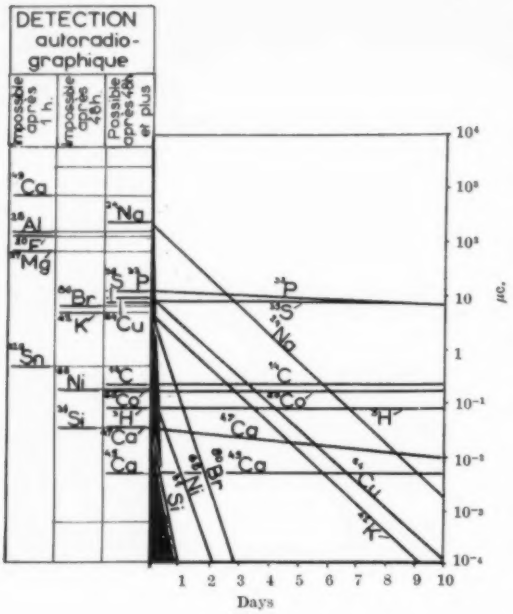


Fig. 4

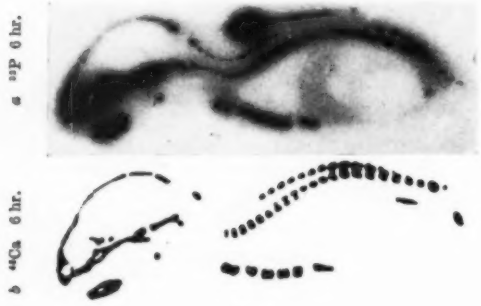


Fig. 5

time a high initial activity, a somewhat lengthy period and sufficient energy to allow of acceptable exposure conditions. The diagram shows that after some minutes, the sodium-24, sulphur-35, phosphorus-32, calcium-47 and -45, copper-64 and potassium-42 are practically alone in combining the three conditions, which confirms the comparison with the results of previous work with certain of these elements injected alone[2-5].

We may thus partly attribute the initial general fog to the even distribution of sodium-24, but its short period must appreciably reduce its autoradiographic efficiency in a few days. Sulphur-35 coming from chlorine-35, of even distribution, must also participate in the general fog.

On the other hand, it is permissible to anticipate bony localizations by activation of calcium and phosphorus in which the skeleton is particularly rich (tricalcium phosphates and apatites). Throughout the first minutes, fluorine-20 (teeth) and calcium-49 probably play an important part. Then phosphorus-32 and calcium-45 and -47 must take up the relay with slighter activity, but with a longer half-life. It should finally be possible to notice a thyroidal localization of iodine-128 during the first hour.

A systematic examination of the autoradiographs confirms these expectations on the whole: by comparing the various reference autoradiographs during a space of time (8-min. exposure), we notice that the intense fog of the first hours (Fig. 1*a*) has practically disappeared in five days (Fig. 1*c*), which enables it to be attributed to elements evenly distributed over periods of less than 24 hr. (sodium-24 and potassium-42). The bony and dental localizations that are perceived from the first hours for exposure times of 1 min. (Fig. 2) remain detectable; on the other hand, up to four weeks for the reference exposure of 8 min. (Fig. 1*h*). The decrease in blackening corresponding to these localizations is attributable to a radioelement of a period of about two weeks, and it thus seems that it is essentially phosphorus-32 which is the cause in this case, much more so than a long-period radioactive calcium, which is, moreover, in a thousand times lesser proportion as shown by the diagram. The comparison with the autoradiographs obtained by the same technique after injecting phosphorus-32 (Fig. 5*a*) and calcium-45 (Fig. 5*b*) confirms this interpretation, for the autoradiograph of the activated rat (Fig. 2) has a striking resemblance to that of the rat that has received the injection of phosphorus-32 (Fig. 5*a*) both by its localizations as well as the absence of sharpness due

Fig. 6

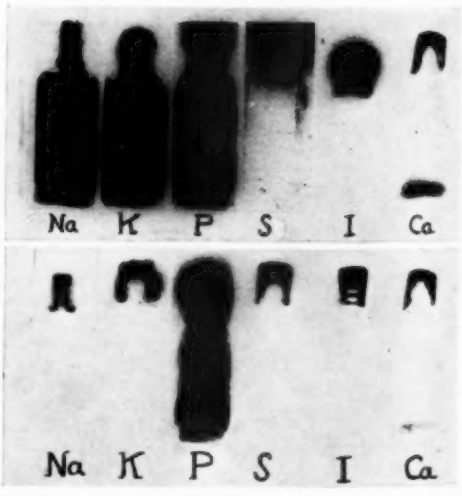


Fig. 7

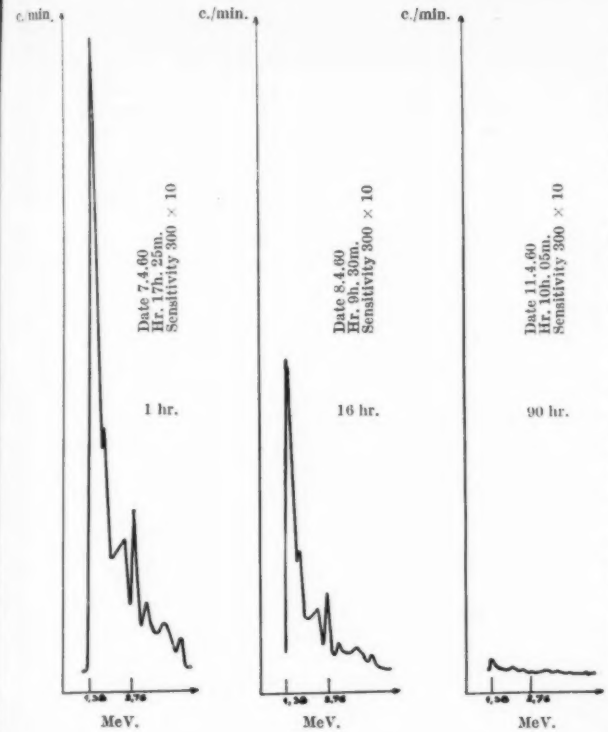


Fig. 8

to the very penetrating beta-ray emission of phosphorus-32. It should be noticed that after several days (Fig. 6) it is possible to find an appreciable background fog with an exposure distinctly greater than the reference exposure (1 hr. 30 min.); the appearance then becomes rigorously identical with that of the autoradiographs following injections of phosphorus-32, which leads one to think that this background fog is due to the activation of cellular phosphorus and more particularly nucleic acids.

As for iodine-128, which should be found in the region of the thyroid, it was not possible to show this in the conditions of these experiments, undoubtedly on account of its very short period.

In order to check these interpretations, we exposed to the neutrons flux plastic flasks of solutions titrated with soda, potash, phosphoric acid, sulphuric acid, iodine and lime, at the same concentration as in the rat's system. The flasks were autoradiographed following the same technique, and we ascertained (Fig. 7*a*) that after equal exposures on the first day, sodium-24, potassium-42 and phosphorus-32 give an intense blackening, sulphur-35, iodine-131, calcium-47 and -45 a slight or zero blackening. On the third day (Fig. 7*b*), with the same exposure time, all the blackenings are practically nil, except for phosphorus-32.

Finally, we carried out the gamma spectrometry of a rat on emerging from the pile and on the following days (Fig. 8). The appearance of the spectrum and its decrease in relation to time in identical spectrographic conditions confirm the relative importance of sodium-24 among the gamma emitters brought into play during the first days[6].

In conclusion, it appears that an exposure to a flux of thermal neutrons must secondarily involve, by the radioactivity induced in the body, a general irradiation of relatively short duration by gamma-rays of sodium-24 and potassium-42, and a much longer irradiation by the beta-rays of phosphorus-32 and, to a certain extent, of calcium-45, essentially localized in the skeleton. This latter conclusion must lead to considering the bone marrow as a critical organ with regard to irradiation by thermal neutrons. At the same time it is advisable to emphasize the preponderating part played by phosphorus-32 in this irradiation, which is both dangerous somatically by the elective irradiation of the bone marrow by beta-rays and genetically by the activation of nucleic acids.

[1] Pellerin, P., *C.R. Acad. Sci.*, **244**, 1555 (1958). Proc. First Unesco Int. Conf., Paris, **3**, 684 (1957).
[2] Pellerin, P., Fallot, P., *et al.*, *Nature*, **184**, 1385 (1959).
[3] Pellerin, P., and Siroux, M. R., *C.R. Acad. Sci.*, **249**, 2125 (1959).
[4] Tubiana, M., Pellerin, P., and Siroux, M. R., *C.R. Acad. Sci.*, **249**, 2875 (1959).
[5] Kellershohn, C., and Pellerin, P., "Strahlenthérapie" (Bad Gastein IV, 1960).
[6] Operation "Teapot", Nevada Test Site. Report of the Test Director Atomic Energy Comm. (1957).

EFFECTS OF LINEAR ENERGY TRANSFER ON THE RADIOLYSIS OF WATER AND HEAVY WATER

By Dr. E. COLLINSON, Prof. F. S. DAINTON, F.R.S., and J. KROH

Department of Physical Chemistry, University, Leeds, 2

THE primary act in the decomposition induced by X- or γ-rays of water may be represented by the equation (1), and earlier work both in these laboratories[1] and elsewhere[2] has established:

$$G_{-H_2O}H_2O \xrightarrow{X,\gamma} G_{H}H + G_{OH}OH + G_{H_2}H_2 + G_{H_2O_2}H_2O_2 \qquad (1)$$

and that when heavy water is used instead of ordinary water, $G_{H_2}/G_{D_2} > G_D/G_H > G_{OD}/G_{OH} > G_{-D_2O}/G_{-H_2O} > 1$. When radiations of very high linear energy transfer are used, the observed yields of hydrogen ($G(H_2)$) and hydrogen peroxide ($G(H_2O_2)$) are much larger, and there is evidence that a significant fraction of the hydroxyl radicals reacts with the hydrogen peroxide to form

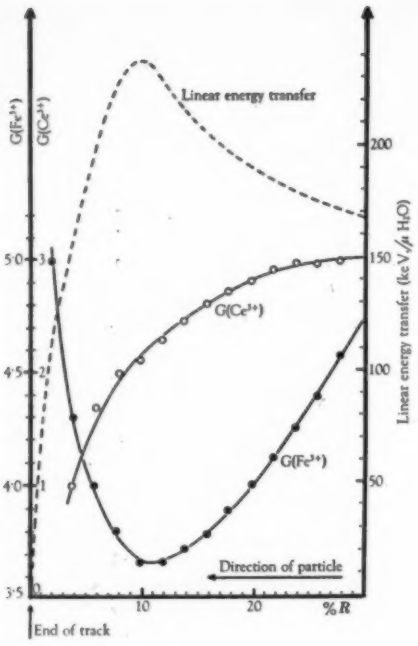


Fig. 1. $G(Fe^{3+})$ and $G(Ce^{3+})$ as a function of the percentage of the α-particle track entering the solution. Broken line is $-dE/dx$ = linear energy transfer at distances from the end of the track obtained by multiplying the abscissa by the range (40μ) of polonium α-particles in water (ref. 4)

$HO_2\cdot$ radicals and water as the track expands and before solutes can 'scavenge' them[3]. Most solutes, therefore, 'see' the primary act in, for example, the α-radiolysis of water as given by equation (2).

$$G\text{–}H_2oH_2O \xrightarrow{\alpha\ \sim\sim\sim} G_H H + G_{OH}OH + G_{HO_2}HO_2 + G_{H_2}H_2 + G_{H_2O_2}H_2O_2 \quad (2)$$

The aim of the work, which is briefly reported here, was to determine (*a*) whether equation (2) is valid and (*b*) the values of $G(H)$, $G(OH)$, $G(HO_2)$, $G(H_2)$ and $G(H_2O_2)$, and the effect on them of changing linear energy transfer and changing the irradiated solvent from ordinary water (H_2O) to heavy water (D_2O).

(1) *Effects of linear energy transfer.* In order to investigate the effect of the changing linear energy transfer along the α-particle track, aqueous solutions of 0·1 *N* sulphuric acid containing either (*a*) ferrous ions or (*b*) ceric ions or (*c*) ceric and thallous ions were irradiated by a flat, external α-particle source (polonium-210), the energy of the α-particles entering the solution being controlled by the use of interposed layers of mica and/or variation in the distance between the sources and the surface of the irradiated solution. An ionization chamber, similar to that described by Miller and Wilkinson[3], was employed for physical dosimetry.

Perhaps the most striking results are those shown in Fig. 1, where $G(Fe^{3+})$ for aerated ferrous sulphate solutions and $G(Ce^{3+})$ for ceric sulphate solutions are plotted against the length of an α-particle track in the solution expressed as a percentage of the length of a 5·3-MeV. α-particle track in the same solution (R).

For comparison we have also plotted the linear energy transfer in keV./μ at various distances from the end of the track, and it is most striking that $G(Fe^{3+})$ passes through a minimum when the initial linear energy transfer of the α-particle track in the solution is close to the maximum possible value for an α-particle in this medium.

The difference in position of the maximum and minimum is not unexpected, since the ordinate G corresponds to:

$$\int_0^{\%R} (dG_x/dx)\, dx$$

where G_x is the value of G for that particular linear energy transfer ($-dE/dx$) at the point on the α-particle track a distance x from the end of the track. The minimum value of $G(Fe^{3+}) = 3{\cdot}65$ is in very good agreement with the value expected from the empirical formulæ of Schuler and Allen[5], which is based on experiments with mono-energetic beams of He^{2+} ions.

The presence of thallous ions in solutions of ceric sulphate does not influence $G(Ce^{3+})$ for α-particles of energy $\leqslant 3$ MeV., and hence *no* hydroxyl radicals are available to this solute, presumably because they are removed by reaction with one another or with molecular products. Since $G(Ce^{3+})$ increases with x (see Fig. 1) we conclude that intra-track reactions removing reducing species are occurring to a decreasing extent and that the back-reaction concerned may well be (3):

$$H + H_2O_2 \rightarrow H_2O + OH \quad (3)$$

When tritium β-particle radiation was used, both the deaerated ferrous system and the ferrous-cupric system were also studied. The value of $G(Ce^{3+})$ was found to be 2·84, which is much lower than Hardwick's value[6] of 4·54, and this and other data lead to values of molecular and radical yields $G_H = 2{\cdot}9$, $G_{OH} = 2{\cdot}1$, $G_{H_2O_2} = 1{\cdot}0$ and $G_{H_2} = 0{\cdot}6$) for acidified water, which are much closer to those for cobalt-60 γ-rays than the values hitherto accepted[7]. Consideration of this result, the data given in Fig. 1 and the value of $G(Ce^{3+})$ for γ-rays, indicates that $G(Ce^{3+})$ has a maximum value at a linear energy transfer intermediate between the mean values for polonium-210 α- and tritium β-particles. This maximum has been predicted by Burch[8], though at lower values of the linear energy transfer.

(2) *Isotope effects.* An isotope effect, similar in magnitude and sign to that observed for γ- and X-rays, was found for tritium β- and polonium α-particles. This effect at first increases with increasing mean linear energy transfer, then passes through a maximum and decreases in the region of mean linear energy transfer corresponding to low-energy α-particles. This is illustrated by the values of the ratio G_D/G_H which are given in parenthesis after the type of radiation: 220-kVp. X-rays (1·11), tritium β-particles (1·14), 3-MeV. α-particles (1·17) and 1·6-MeV. α-particles (1·04).

Associated with this effect are differences in the initial rates of formation of deuterium and hydrogen peroxides, and the steady-state concentrations of these two compounds in aerated heavy and ordinary

water irradiated with tritium β-particles. Although deuterium peroxide is initially formed at about the same rate, the steady-state concentration ultimately reached is higher, and measurements of the decomposition induced by irradiation of $\sim 10^{-3}$ *M* deuterium peroxide solution in heavy water, and hydrogen peroxide solution in ordinary water, showed that this effect is due to a more rapid decomposition of the latter.

Full experimental details and further discussion of these experiments will be published elsewhere.

We are indebted to the Polish Government and the Rockefeller Foundation for financial aid which made this work possible.

[1] Armstrong, Collinson, and Dainton, *Trans. Farad. Soc.*, **55**, 1375 (1959). Coatsworth, Collinson and Dainton, *ibid.*, **56**, 1008 (1960).
[2] Mahlman and Boyle, *J. Amer. Chem. Soc.*, **80**, 773 (1958).
[3] Miller and Wilkinson, *Trans. Farad. Soc.*, **50**, 690 (1954).
[4] Holloway and Livingston, *Phys. Rev.*, **54**, 18 (1938).
[5] Schuler and Allen, *J. Amer. Chem. Soc.*, **79**, 1565 (1957).
[6] Hardwick, *J. Chem. Phys.*, **31**, 226 (1959).
[7] Allen, *Radiation Res.*, **1**, 85 (1954).
[8] Burch, *Radiation Res.*, **11**, 481 (1959).

ORIENTING EFFECTS IN OCTAHEDRAL AQUATION

By Sir CHRISTOPHER INGOLD, F.R.S., Prof. R. S. NYHOLM, F.R.S., and Dr. M. L. TOBE
Department of Chemistry, University College, London

IN three recent reviews of octahedral substitution[1], the subjects considered include aquation, which subsequent work[2] seems now to have appreciably clarified. This article is written because it appears possible to discuss the mechanism of aquation with more assurance than before, to interpret more fully an extended pattern of rate data, and to offer the first stereokinetic rule applicable to octahedral substitutions.

(1) Experimental Data

The experimental data are of two kinds, namely, rates of aquation, and the proportions of isomeric products formed by aquation. As to the latter, it has not always been appreciated that the products formed may be different from the products found, because the initial products undergo isomeric changes at rates often comparable to those of their formation.

In attempting to interpret these phenomena, our starting point is still the observation[3] concerning cobalt (III) aquations of the form:

$$[\mathrm{Co\ en_2}\ A\ X]^{+} + \mathrm{H_2O} \rightarrow [\mathrm{Co\ en_2}\ A\ \mathrm{OH_2}]^{++} + X^{-}$$

that, with a constant replaced ligand *X*, a constant stereochemical relation, *cis* or *trans*, between *X* and the 'orienting' ligand *A*, and a succession of ligands *A*, taken in a presumable order of decreasing electron supply to, or increasing electron withdrawal from, the metal, the rate of aquation at first falls sharply and then rises sharply along the series. This can be illustrated more fully than before, as it is in the third column of Table 1 (en = ethylenediamine).

(2) Duality of Mechanism

Following the lines of an early theoretical treatment of similar patterns of kinetic phenomena in organic chemistry, rates such as those shown in Table 1 have been schematically plotted[3,1a,b,c] on two curves which intersect at a rate minimum; and the falling and rising curves have been interpreted as indicating different mechanisms, having different, indeed qualitatively opposite, polar requirements. Along the falling curve, an excess of electron export from the reaction site, over any electron import there may be to it, must be required in order to bring the system to the transition state: obviously, ligand loss is in the lead, as is consistent with the presumed mechanism, S_N1. Along the rising curve, an excess of electron import to the reaction site is needed in order to produce the transition state: here the binding of water must be in the lead, and the mechanism bimolecular, as is the assigned mechanism, S_N2.

In order to develop this general approach in more detail, not only with respect to the rate pattern but also in regard to the stereochemical orientation of aquation, for which the data are in the fifth column of Table 1, it is necessary to consider the electronic constitutions of the orienting ligands, and so to deduce the types of polar properties they should possess, and the effects of such properties on rate and orientation in the two mechanisms of aquation. We shall have to consider three different types of polar properties.

Table 1. Rates of (k_1 in sec.$^{-1}$ at 25°), and Isomer Ratios (per cent Configurational Change) of First-formed Products in, the Aqueous Reactions

$$[\mathrm{Co\ en_2}\ A\ X]^{+} + \mathrm{H_2O} \rightarrow [\mathrm{Co\ en_2}\ A\ \mathrm{OH_2}]^{++} + X^{-}$$

X	*A*	$10^7 k_1$	Note.	Ref.	Per cent *trans*	Note.	Ref.	Mech.
cis-Cl	OH	130,000		9	0?	*a*	6	
,,	N_3	2,400		12	0	–	12	
,,	Cl	1,250	*b*	9	0	*c*	6	S_N1
,,	NCS	114		11	0	*d*	11	
,,	NH_3	~5	*e*	8	0		14	
,,	OH_2	~150	*f*	4, 9	—		—	S_N2
,,	NO_3	1,120		3	0		3	
cis-Br	NCS	240		11	0		11	S_N1
,,	NH_3	15		8	0		14	S_N2
cis-NO_3	NH_3	180		8	0		14	S_N2
					Per cent *cis*			
trans-Cl	OH	14,000		9	some		13	
,,	N_3	2,500		12	20		12	S_N1[h]
,,	Cl	160	*b*	9	some		5	
,,	NCS	0·5		7	<50	*g*	11	
,,	NH_3	4		10	0		10	S_N2
,,	NO_3	9,800		3	0		3	
trans-Br	NCS	1·7		7	43		7	S_N1
,,	NH_3	9		10	0		10	S_N2
,,	NO_3	46,000		14	0		14	
trans-NO_3	NH_3	63		10	0		10	S_N2

(*a*) It is shown, though without a quantitative determination, that the initial product is at least largely *cis*.
(*b*) Half the observed rate, that is, the rate of replacement of one 'marked' chlorine atom.
(*c*) With the optically active substrate, there is complete retention of optical activity, and almost certainly of optical configuration.
(*d*) With the optically active substrate, there is a large, perhaps complete, retention of optical activity and configuration.
(*e*) Observed rate at 62·6° calculated for 25° with $E = 23$ kcal./mole.
(*f*) Half the observed rate as given for 30°.
(*g*) Probably not more than 70 per cent of *cis*-product.
(*h*) Possibly not exclusively S_N1 for *trans*-N_3 (text, section 6).

(3) Inductive Effects ($\pm I$) of Ligands

Under the term 'inductive' effects, we include all electrostatically induced deformation of electron shells within the atoms, but exclude all electron-transfer, or 'conjugative', processes.

On grounds well worked over in organic chemistry, we can at once make relative assessments of inductive polarity among some of the orienting groups of concern to us. Thus we can write the following order of increasing inductive electro-negativity (electron attraction), or, what is synonymous (for in these considerations, which are wholly relative, it is convenient to retain the alternative modes of expression), diminishing electro-positivity (electron repulsion): OH, Cl, NO_2, NH_3^+, OH_2^+. The groups N_3 and NCS need further consideration. It seems plausible to assume that the fractional charge, negative in N_3 and positive in NCS, conferred on the first atoms of the groups by the second-written and (as we think) less weighty structures of the canonical pairs:

$$\overset{+}{.}N=\overset{-}{N}=N, \quad .N-\overset{-}{N}\overset{+}{\equiv}N, \text{ and } .N=C=S, \quad .N\overset{+}{\equiv}\overset{-}{C}-S,$$

will be more important for induction than the more distant, formally integral charges. We can then set down the electro-positivity differences $N_3 > NCS > NO_2$ and $N_3 > Cl$, and so build up the following more extensive series, in which some theoretically unresolved dubieties still remain:

$$\underset{\longleftarrow\ +I\ \longrightarrow}{OH,\ N_3 > Cl,\ NCS > NO_2 >} \underbrace{NH_3^+,\ en_{1/2}^+}_{\text{standard}} \underset{-I}{> OH_2^+}$$

Electropositivity sequence

There is no convenient natural zero of electro-positivity or electronegativity within our range of relative structural effects. We therefore choose a working zero. Among the complexes to which Table 1 refers, most of the octahedral positions are occupied by $en_{1/2}^+$ groups, and in another, less fully investigated but probably similar series, most are occupied by NH_3^+ groups. Electrostatically, these ligands must be much alike, and we could quite well adopt either as our inductive zero, as indicated in the sequence written above. Most of our orienting ligands thus become classified as inductively electro-positive. The exceptions are NH_3^+, which we take as inductively neutral, and OH_2^+, which on this scale is electronegative.

An inductive effect acts, not on stereospecifically selected orbitals but on the general electrostatic situation, and most strongly on the most polarizable electrons of the nearest atom. We may plausibly take these to be the unshared electrons of the quantum groups contributing to the valency shell of cobalt; in particular, the $3d_\epsilon$ sub-shell of six unshared electrons, which surrounds the atom, filling up the spaces between the ligands. An inductively electropositive orienting ligand will press this electron sub-shell in all directions away from itself, between the other ligands, so causing it to encroach the more on all of them, and more especially on the *trans*-ligand. (This would be a so-called '*trans*-effect'.)

Such electropositive electron displacement will evidently affect substitution mechanism by promoting a loosening of the replaced ligand, and by retarding the entry of water. It follows that it will promote S_N1, and retard S_N2 aquation.

The summary of these conclusions is that the $+I$ effect of orienting ligands will, in the order of the electropositivity sequence given above, promote S_N1 and retard S_N2 aquation, and will do all this more strongly in *trans* than in *cis*-positions.

(4) Electromeric Effect ($+E$) of Ligands

Two conjugative, or electron-migratory, processes are factors in the overall polarity of our ligands. In this section we shall consider an electropositive conjugative effect[3,15], that is, one which transfers electrons from the ligand to the metal. It is permitted to ligands which have an unshared pair of electrons on the atom adjoining the metal. In the initial state of the reacting system, the metal has no empty orbital with which it could accept a share of such an electron pair. But in the transition state, provided that the incoming water does not become bound too early, the metal will have the emptying orbital of the outgoing ligand. Thus, if we disregard hyperconjugation, the conjugative effect under consideration is necessarily absent from the initial state, but possibly present in the transition state. That is why we sub-classify it as an electromeric effect ($+E$), rather than as a mesomeric effect ($+M$).

Among the orienting ligands we have examined, four, namely, OH, N_3, Cl and NCS, possess unshared electrons in a location in which they could conjugate as described. Theory is equivocal about the relative conjugative powers of these groups. We might expect that their property of electropositive conjugation would be ordered with some reflexion of the inductive electropositivity sequence, OH, $N_3 > Cl$, NCS. However, N_3 might have to be moved down, and NCS up, in the conjugative sequence, because the adjacent-charge rule restricts conjugation by N_3 except in its minor canonical structure, whereas NCS conjugates through its major structure in which the atoms are uncharged. Formally, the group OH_2^+ should bring up the rear of this series; but we regard the unshared electrons of that group, like those of SMe_2^+ in organic chemistry, as incapable of conjugation, so that OH_2^+ is not an effective member of the class.

Since electromeric conjugation $+E$ requires an emptying bond-orbital, it will enter into, and facilitate, only S_N1 aquations, which are initiated by ligand loss. It will take no part in S_N2 aquations, neither hindering nor helping them.

A stereochemical condition is involved in the $+E$-effect; for conjugating orbitals must be non-orthogonal. In the tetrahedral binding situations of organic chemistry, this condition is commonly fulfilled; but the prohibition of orthogonality is known, for example, in the cases summarized under 'Bredt's rule'. In octahedral situations, the rectangular bonding introduces frequent orthogonality restrictions, and we have one here. For the orbital of the ligand electrons which might conjugate with an emptying octahedral bond-orbital is orthogonal to the *trans* octahedral orbital and non-orthogonal only to the *cis*-orbitals. Thus, electromeric conjugation $+E$ is restricted to *cis*-related ligands (a '*cis*-effect').

This stereospecificity has a further possible consequence. For, if the group, which is normally the most easily replaced of the groups present, is *trans*-related to the orienting ligand, the latter may cause, in a normally less easily loosened *cis*-group, a degree

of prior loosening, insufficient for its own replacement, but sufficient to allow it to engage in a tentative or complete edge-displacement involving loss of the labile *trans*-group. Thus, the substitution could involve some rearrangement, a *trans*-factor giving a *cis*-aquo-product. Such rearrangements are evidently confined to substrates with a replaced group X *trans*-situated with respect to a $+E$-type orienting group A. For a fixed orienting group, the greater the normal ease of loosening of the replaced group, the less extensive should be the rearrangement. Among our replaced groups, provided that they are compared in the same structural environment, the order of extent of rearrangement on aquation should be $Cl > Br > NO_3$.

In summary, we may say that the $+E$ effect of the orienting ligands, OH, N_3, Cl and NCS, will leave untouched S_N2 aquations, but will promote S_N1 aquations, chiefly of substrates having *cis*-related orienting and replaced groups; but in the isomeric *trans*-substrates it will induce a tendency to substitution with rearrangement, in the order $Cl > Br > NO_3$ of replaced groups.

(5) Conjugative Effect ($-T$) of Ligands

This electronegative form of electron-transfer involves conjugation the other way round, that is, between unshared electrons of the metal, and an orbital which can be emptied sufficiently in the orienting ligand to allow the latter to share them[3]. The unshared $3d_\varepsilon$ sub-shell of cobalt is the source of the electrons. Any ligand having a double bond transformable to a dipolar bond the positive end of which adjoins the metal will be able to share one pair of such electrons. At least one of the three $3d_\varepsilon$ orbitals of the metal is always non-orthogonal to the receiving ligand orbital, so that at least one pair of electrons is always available for sharing. Hence this form of conjugation belongs to the ground-state of the complex, that is, to the initial state of the reaction: in this aspect, we would sub-classify it as a mesomeric effect ($-M$). Depending on the polar needs of the reaction mechanism, it will make the transition state either easier or harder to reach, and so it will either facilitate or retard reaction. In the former case only, the possibility arises that an intensification of the conjugation will stabilize, and therefore occur in, the transition state, so making it still more accessible, and providing a further facilitation that we would sub-classify as an electromeric effect ($-E$). The conjugative effect ($-T$) includes both its mesomeric and electromeric aspects.

The only orienting ligands of those used in the present work, which have the electronic structures permitting electronegative conjugation, are N_3 and NO_3. Considerations familiar in organic chemistry lead us to place their conjugative electronegativities in the order, $N_3 < NO_3$.

By retracting part of the cobalt $3d_\varepsilon$ shell, these groups will facilitate the water uptake which initiates S_N2 aquations, and will resist the ligand loss with which S_N1 aquations must commence.

Because this conjugation of the orienting ligand is with the unshared-electron sub-shell, rather than with an orbital binding another ligand, it is not sharply stereospecific. But by withdrawing the $3d_\varepsilon$ sub-shell largely from the spaces between the *trans*-ligand and the four *cis*-ligands, it should exert its strongest influence in the *trans*-position (another '*trans*-effect').

In summary, the electronegative conjugative effect of orienting ligands, in the order $N_3 < NO_3$, will inhibit S_N1 and promote S_N2 aquations, acting thus more strongly at *trans*- than at *cis*-positions.

(6) Polar Effects on Rate

In trying to anticipate the results that might follow from the joint action of the three polar factors (sections 3–5), our main guide is organic chemical experience to the effect that, leaving hyperconjugation out of account, conjugation is nearly always more powerful than induction in the control of reactions. Thus, in arranging the sequence of orienting groups used in Table 1, we begin with the $+E$ and end with the $-T$ groups, otherwise using the order of decreasing electropositivity throughout. The major uncertainty which then remains is in the placing of the N_3 group, which belongs to both conjugative types, and possibly ought to have been entered twice in the series.

The fall of rate with decreasing electropositivity, and the succeeding rise with increasing electronegativity, have been noted before, and are the basis of the assignments of mechanism suggested in the last column of Table 1. We can now see further that, over the falling part of the rate series, rates for *cis*-isomers exceed those for *trans*, while over the rising part, the rates of *trans*-isomers are the greater, with the result that the rate minimum shifts one place on passing from the *cis*-series to the *trans*. This accords with our anticipation of stereospecific $+E$ *cis*-activations in S_N1 aquations, and of favoured $-T$ *trans*-activations in S_N2 aquations. The group N_3 remains observationally marginal; but it is theoretically ambiguous, and part of the rate for the *trans*-complex may, despite the assignment of mechanism entered in the last column of Table 1 (but see note *h*), be that of an S_N2 aquation.

(7) Polar Effects on Orientation

In aquation, the predominating tendency is to retention of configuration. For *cis*-substrates, such retention, including that of optical configuration where investigated, is total so far as is known. We can understand the general tendency on the ground that the aqueous solvation shell of the complex ion will contain an inner layer of water more or less embedded among the ligands in the structure, and that such a layer is likely to include at least one water molecule in such close juxtaposition to the replaced group that substitution, whether with loosening or binding in the lead, can be effected simply by a local exchange of these interactions, and thus without the necessity for any more widespread stereochemical disturbance.

The exceptions to total retention of configuration occur among the *trans*-substrates; and there, they are confined to those in which the orienting group belongs to the $+E$ class; but they do include all examples of this class. It can also be said that the configurational changes arise only in, but in all, those aquations of *trans*-substrates to which, on account of the rate trend, an S_N1 mechanism has been assigned. This is so much in line with what would be expected from the theory of *cis*-specificity in the $+E$-activation of S_N1 aquations that it does not seem unreasonable to apply theoretically guided

'induction' to rather few experimental results in proposing the following statement of requirements for aquation with rearrangement: In octahedral aquations which replace X in filled-sub-shell complexes MR_4AX of a transition metal, M, configuration will be totally preserved, unless A and X are *trans*, and A but not R has unshared electrons adjoining M.

It is implied in the theoretical basis of this rule that the conditions for rearrangement which it gives are necessary but not sufficient. Other requirements can be foreseen, as that R must be labile enough to be loosened by the available *cis*-activation, and X not so labile as to be lost altogether independently of R loosening. However, such conditions are not sufficiently definable in terms of constitution to be incorporated in a rule, and hence we leave ours as a permissive rule.

[1] (*a*) Basolo, F., and Pearson, R. G., "Mechanism of Inorganic Reactions", Chap. 3 (John Wiley and Sons, New York, 1958). (*b*) Ingold, C. K., "Substitution at Elements other than Carbon", Chap. 1 (Weizmann Science Press, Jerusalem, 1959). (*c*) "Theoretical Organic Chemistry", 84 (Butterworths Scientific Publications, London, 1959).

[2] Tobe, M. L., *J. Chem. Soc.*, 3776 (1959); and forthcoming papers, some jointly with Baldwin, M. E., and Staples, P. J.

[3] Asperger, S., and Ingold, C. K., *J. Chem. Soc.*, 2862 (1956).

[4] Mathieu, J.-P., *Bull. Soc. Chim., France*, V, **3**, 2121 (1936).

[5] Mathieu, J.-P., *Bull. Soc. Chim., France*, V, **3**, 2152 (1936).

[6] Mathieu, J.-P., *Bull. Soc. Chim., France*, V, **3**, 687 (1937).

[7] Ingold, C. K., Nyholm, R. S., and Tobe, M. L., *J. Chem. Soc.*, 1691 (1956).

[8] Nyholm, R. S., and Tobe, M. L., *J. Chem. Soc.*, 1707 (1956).

[9] Pearson, R. G., Meeker, R. E., and Basolo, F., *J. Amer. Chem. Soc.*, **78**, 2673 (1956).

[10] Tobe, M. L., *J. Chem. Soc.*, 3776 (1959).

[11] Baldwin, M. E., and Tobe, M. L., *J. Chem. Soc.* (in the press).

[12] Staples, P. J., and Tobe, M. L., *J. Chem. Soc.* (in the press).

[13] Baldwin, M. E., and Tobe, M. L. (unpublished observations).

[14] Tobe, M. L. (unpublished observations).

[15] Pearson, R. G., and Basolo, F., *J. Amer. Chem. Soc.*, **78**, 4878 (1956).

FALL-OUT CÆSIUM IN SURFACE SEA WATER OFF THE CALIFORNIA COAST (1959–60) BY GAMMA-RAY MEASUREMENTS

By Dr. THEODORE R. FOLSOM, Dr. G. J. MOHANRAO and PERRIN WINCHELL

Scripps Institution of Oceanography, University of California, La Jolla, California

STRONTIUM-90 and cæsium-137 decay at very similar rates and relatively slowly, half in about thirty years, or less than 2 per cent a year. The rate at which fall-out is reaching the land surface has been followed by extensive measurement[1] of these nuclides in soil specimens and in various rain samples. On the other hand, the collection of similar data concerning fall-out entering the sea has been seriously limited by measurement difficulties, arising mainly from the excessive dilution and from the presence in sea water of relatively larger amounts of natural radioactivities and relatively enormous amounts of stable nuclides that interfere with chemical concentration and purification.

Fortunately for study of fall-out phenomena, the dispersal of these long-lived fission products after they have entered the sea is also of great interest in the study of food-chains, especially those directly influencing fisheries, and also in the oceanographic study of water movements and mixing. Yamagata has developed a successful technique for measuring cæsium-137 in sea water through its beta-ray after numerous steps of chemical purification; recently he has reported[2] his measurements of the recent distribution of cæsium-137 in waters close to the coast of Japan. Bowen and Sugihara, of Woods Hole Oceanographic Institution, have studied fall-out constituents in the sea for several years and have reported[3] recently on the horizontal and vertical distribution of strontium-90 in the Atlantic Ocean. They point out that their vertical profiles indicate downward mixing to depths of 300–700 metres at a rate much more rapid than might be predicted from existing radiocarbon measurements. They show that a significant amount of strontium-90 has penetrated even to a depth of 1,000 metres.

The oceans are very large, and many more of this sort of data must be collected before generalizations regarding either the arrival or dispersal of fall-out become convincing. Efforts at the Scripps Institution, therefore, have centred around simplifying the chemical assay required, adapting it to shipboard use, and the application of electronic aids wherever possible. Whereas strontium-90 emits only beta-rays and its assay in sea water is tedious, cæsium-137 (which falls into the sea at about the same rate) has both beta- and gamma-emission. To utilize the beta-ray as Yamagata and others have done, the trace of radiocæsium must be chemically separated from the large amount of potassium present in sea water, including the natural beta-emitter potassium-40. On the other hand, the modern scintillation spectrometer has no trouble resolving the gamma-ray of cæsium-137 (0·66 MeV.) in the presence of much larger amounts of potassium-40 (1·46 MeV.). The assay problem, therefore, reduces to one of concentrating sea water cæsium in a way convenient for gamma-ray spectrometry. Gustafson, Marinelli and Brar[4] at the Argonne National Laboratory have shown how low-level gamma-ray assays can be made from bulky specimens by use of large scintillation detectors. It was found at Scripps that the radiocæsium in a barrel of sea water, brought down together with roughly 30 per cent of the potassium by the mere addition of sodium cobaltinitrite, could be collected as a precipitate having a volume of about 250 ml. This wet material, placed near a 3-in. diameter sodium iodide scintillation crystal, gave accurate and reproducible measure of the cæsium content as could be established by adding known amounts of radiocæsium to controls. For this sort of work, a 256-channel gamma-ray spectrometer is now available at Scripps; a digital computer accessory developed at Scripps now permits storage of information on short magnetic tape loops and gives means for the rapid comparison between gamma spectra and the elimination of background effects. At present the precipitate is allowed to settle overnight, collected after decantation and then exposed to a 3-in. crystal, generally overnight. It is expected that gamma

spectrographs will be made in less than 2 hr. by the use of larger crystals; and it is planned to have the initial precipitation carried out on board the research ship so that only the concentrated precipitate need be brought back from the longer expeditions.

Details of the procedure will appear elsewhere. Satisfactory reproduction of results has been demonstrated; the difference between the assays of five 200-litre replicate controls was less than 11 per cent. It now appears unnecessary to resort to the use of such large samples; nevertheless, several uncertainties in the early work were avoided by this means. For example, storage in full-sized steel oil drums for one month was found to cause a loss of about 20 per cent of the radiocæsium to the walls; and storage for one week in a rubber barrel caused a loss of about 13 per cent. Losses of this sort may be serious when small samples are stored for a long period, but, of course, are eliminated by immediate chemical precipitation.

Table 1 gives the results of twenty preliminary assays made on 200-litre sea water samples taken just beyond the surf zone (300 metres from shore) at Scripps pier. Serial 10 was deliberately taken when the water was brown with terrestrial mud from a heavy local rain; it is not significantly exceptional in cæsium content.

The average cæsium-137 is 97 micromicrocuries per kilo litre (97 μμc./kl.).

Table 2 shows the results for water carefully collected in 200-litre aliquots in the open sea many miles from shore. The average concentration is 138 μμc./kl.

For comparison there are two groups of measurements made by Yamagata[2] concerning Japanese waters. He deduced from industrial salt concentrates that coastal waters early in 1958 contained cæsium-137 in the amounts 70–150 μμc./kl. Later, by direct low-level beta technique, he measured the concentration in 1959 surface sea water taken from salt works, reporting the average cæsium-137 from fifteen samples as 380 μμc./kl.

Of course, too much should not be expected from cursory comparisons between these preliminary sets of measurements. It is believed that the oceanographic phenomenon called 'upwelling' does not occur in the region where the samples of Table 2 were taken; nevertheless, these waters may have been

Table 1. Concentration of Cæsium-137 in Sea Water from Scripps Pier

No.	Date collected	CsCl carrier mgm./l.	Cs-137 μμc./kl.
1	11/30/59	0	76
2	12/ 2/59	0	123
3	12/ 3/59	0	104
4	12/11/59	100	163
5	1/ 2/60	0	67
6	1/16/60	0	90
7	1/23/60	20	135
8	2/ 3/60	30	145
9	2/ 4/60	0	108
10	2/12/60	25	108
11	2/15/60	0	108
12	3/ 4/60	0	99
13	3/12/60	0	45
14	3/17/60	0	46
15	3/18/60	0	67
16	3/25/60	0	79
17	4/ 9/60	0	76
18	4/15/60	0	71
19	4/22/60	0	86
20	4/27/60	0	138
		Average	97

Table 2. Concentration of Cæsium-137 in Samples from the Open Sea

Serial No.	Date collected	Position Lat. N.	Position Long. W.	Distance from coast, miles	Cs-137 μμc./kl.
1	12/10/59	33° 55′	121° 49′	75	81
2	12/17/59	31° 08′	120° 55′	215	163
3	12/17/59	31° 07′	122° 26′	300	161
4	1/31/60	38° 02′	127° 50′	200	152
5	1/31/60	38° 02′	127° 50′	200	124
6	3/8/60	30° 53′	116° 59′	35	87
7	3/15/60	24° 40′	114° 02′	100	144
8	3/18/60	31° 05′	122° 39′	300	150
9	3/19/60	30° 32′	122° 13′	300	141
10	3/21/60	26° 13′	118° 27′	200	230
11	3/22/60	29° 42′	120° 44′	250	120
12	3/25/60	28° 14′	119° 28′	220	100
				Average	138

Sample No. 5 was collected in a neoprene drum. The rest in steel drums.

influenced by local vertical mixing of some sort, perhaps at a place thousands of miles to the north of the sampling position. The range of variation in concentrations which appear in these tables as well as in Yamagata's 1959 measurements (240–650 μμc./kl.) should be a warning to those who might hope to establish for specific oceanic areas the average vertical profile of radiocæsium (or radiostrontium or any other water tag) with only a few measurements.

The increase reported in cæsium in Japanese waters between 1958 and 1959 corresponds to an increase in weapon-testing activity and to a world-wide increase in fall-out. However, the difference between the California and the Japanese surface concentrations might be due to several factors; certainly to be considered are the reports of consistently higher local fall-out in Japan, and also are the differences of positions of Japan and California in the general circulation of the Pacific relative to the weapons proving-grounds. Certainly, the behaviour of a water tag in surface-water must be explored first, but these waters move faster horizontally; much more information concerning transport and mixing can be obtained when samples from several depths can be examined. Plans therefore have been made to sample Pacific waters to depths where there is little motion.

Arrival of fall-out, being associated with rainfall, is at best spotty. However, during the past eighteen months there has been a moratorium in weapons tests; and over this period there have not appeared the large peak values witnessed during the previous years. Advantage, of course, should be taken of this simplifying circumstance to establish background values related to the ocean. Another factor arising from the moratorium should be mentioned as it concerns the measurement of radiocæsium in sea water. During the past year the shorter-lived fission products have become so attenuated that essentially nothing needs to be done now to eliminate their interference with cæsium-137 in a gamma-ray spectral analysis. Prior to this recent, happy period, the obscuring effects of fresh fall-out constituents were combated at Scripps either by additional chemical treatment, or by fullest use of the digital computer already mentioned and developed for just this purpose.

The matter of vertical biological transport cannot be overlooked. However, one can present an argument for neglecting the biological transport of radiocæsium perhaps as strong as that offered by Bowen and Sugihara for ignoring this contribution in the

case of radiostrontium. They argued that biological transport cannot be important because of the presence of large amounts of stable strontium and calcium in sea water. Cæsium, too, is notably soluble; only traces of the radionuclide enter as fall-out and these must share with large amounts (about 0·002 mgm./litre) of stable cæsium; and also there is present in sea water much larger amounts of potassium (about 380 mgm./litre). It is common experience that potassium and cæsium are found together in many reactions—organic and inorganic. Still, a considerable loss of radiocæsium to surfaces has been observed in the actual handling of sea water specimens, and too little is now known about the behaviour of stable cæsium in the actual seas. Fortunately, the chemical behaviour of cæsium is quite different from that of strontium; exploration based upon the progress of fall-out in the ocean should exploit this. At the outset, sampling of radiostrontium should go along with that for radiocæsium.

Various aspects of this work have been supported by the United States Atomic Energy Commission (Contract No. *AT*(11-1)-34, Project Agreement No. 56), and by the United States Office of Naval Research (Contract 233(34), Amendments No. 7,8,9). We are grateful for suggestions that have come personally from Drs. V. T. Bowen, T. T. Sugihara and N. Yamagata. We wish to thank D. C. Martin for related preliminary studies, and also Barbara Edwards, William Hartin and Richard Schwartzlose for skilful technical assistance.

[1] Gustafson, P. F., *Science*, **130**, 1404 (1959).
[2] Yamagata, N., *Nature*, **184**, 1813 (1959).
[3] Bowen, V. T., and Sugihara, T. T., *Nature*, **186**, 71 (1960).
[4] Gustafson, P. F., Marinelli, L. D., and Brar, S. S., *Science*, **127**, 1240 (1958).

VISCOSITY INCREMENTS OF NON-IONIZED MOLECULES

By ALFRED POLSON

Council for Scientific and Industrial Research and University of Cape Town Virus Research Unit, Medical School, Cape Town

A DISTINCTIVE property of colloidally dispersed substances as opposed to crystalloids is their relatively higher intrinsic viscosity or viscosity increment. The reason for this is that the medium in which the macromolecular particles are dispersed may be regarded as continuous on account of the great difference in size between the suspended particles and those of the medium. For such systems the frictional forces encountered by a particle moving through such a medium may be calculated from the well-known Stokes's equation. Low molecular substances (so-called crystalloids) do not obey Stokes's equation since the medium in which the molecules are dispersed may no longer be regarded as continuous. When these low molecular substances move through a medium composed of molecules of similar size they will encounter less friction than colloid particles, by slipping into empty spaces in the dispersion medium.

In viscosity and diffusion measurements with crystalloids, the slipping effect will show itself as a low-viscosity increment $[\eta]$ or as an abnormally high diffusion-rate.

Viscosity Increments of Low Molecular Substances

As might be expected, the departure from the ideal or macroscopic friction law of Stokes becomes more pronounced the more closely the molecular diameters of the dispersed particles approach those of the dispersion medium. In Table 1 and Fig. 1 are shown the viscosity increments of low and high molecular substances in water at 20° C. as a function of their molecular volumes expressed as log (MV).

The $[\eta]$ for the low molecular substances are greatly dependent on the molecular volumes, being almost zero for urea and rising to 0·024 for sucrose, and 0·035 for norleucine. An interesting conclusion may be drawn regarding the molecular state of water from the $[\eta]$ log (MV) curves. Let (MV) be the molecular volume of the dissolved substance and (mv) that of the dispersion medium. We may then write:

$$[\eta] = F[(MV) - (mv)]$$

where F is an unknown factor. Whatever F may be, $[\eta]$ will approach zero when (MV) approaches (mv). Knowing (MV) when $[\eta] = 0$ we may estimate (mv).

From Fig. 1 it is obvious that the $[\eta]$, log (MV) relationship for low molecular compounds is presented by a curved wedge which pinpoints on the ordinate at log $(MV) = 1{\cdot}58$, indicating that the $[\eta]$ will equal zero when the substance under investigation

Table 1. Viscosity Increments and Molar Volumes of a Number of Crystalloidal and Colloidal Substances measured in Water and Electrolyte Solutions, respectively

Substance	Mol. wt.	Mol. vol.	Viscosity increment
Urea	60	45·1	0·002
Glycine	75	43·5	0·0104
α-Alanine	89	60·6	0·024
β-Alanine	89	58·9	0·020
Glycerol	93	73·8	0·023
Oxalic acid	126	76·4	0·012
α-Amino-butyric acid	103	76·5	0·028
Valine	117	91·3	0·032
Norvaline	117	92·7	0·035
Norleucine	131	108·4	0·035
Glucose	180	111·9	0·086
Citric acid	210	136·3	0·0174
Sucrose	346	209·9	0·0243
Gliadin fraction	27,500	19,525	0·105
β-Lactoglobulin	41,800	30,514	0·045
Ovalbumin	43,300	31,600	0·0427
Hæmoglobin	64,000	46,720	0·0403
Serum albumin	70,000	51,100	0·0488
Amandin	329,000	240,170	0·0525
Thyroglobulin	640,000	467,200	0·071
Jasus lalandi hæmoc.	490,000	357,700	0·0408
H. pomatia hæmoc.*	8,900,000	6,497,000	0·052

The molar volumes of the crystalloids were obtained from the publication by Longsworth (ref. 1) and from "Handbook of Chemistry and Physics" (1958–59), the molecular weights of the proteins from Svedberg and Pedersen (ref. 2), the viscosity increments from papers of Polson (refs. 3 and 4) and unpublished measurements.

* Brohult (ref. 5).

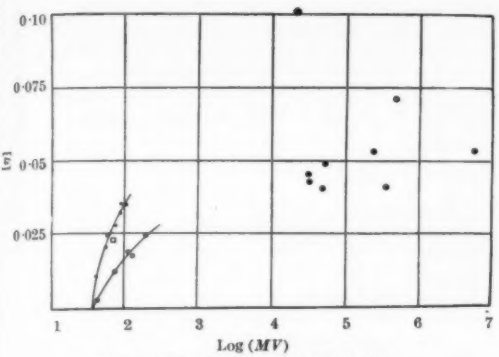


Fig. 1. Variation of $[\eta]$ with log (MV)

The large solid circular spots are the $[\eta]$'s of the protein molecules, the small full stops those of the aliphatic amino-acids, and the open circles those of the compact molecules. The open square is the $[\eta]$ of glycerol

has a molar volume of approximately 38. As the viscosity measurements were all made in distilled water at 20° C., it indicates that water has a molar volume of 38 at 20° C., therefore a molecular weight of 38 or a chemical structure of $(H_2O)_2$. This is confirmatory evidence of the well-established fact that water molecules form aggregates of the type $(H_2O)_n$ where $n = 1, 2, 3$, etc. At low temperatures the higher polymers predominate, and at elevated thermal levels the monomers are in excess.

It is interesting to note that the top of the wedge shows the variation of $[\eta]$ with log (MV) for the aliphatic amino-acids which may be regarded as composed of rod-shaped particles, while the lower curve presents the $[\eta]$ of the molecules with more compact structures.

Viscosity Increments of Colloidal Particles

From Fig. 1 it is apparent that the $[\eta]$'s of the macromolecules are independent of molecular volume. The scattering around the mean value may be ascribed to variation in states of hydration or in particle shape.

It has been shown in a previous communication[4] that $[\eta]$, the molecular weight M, and the diffusion constant D are interrelated by the following equation:

$$[\eta] = \frac{k}{MD^3}$$

where k is an empirical constant and equal to $8{\cdot}06 \times 10^{-16}$. This equation was derived from the Stokes–Einstein diffusion equation and from Einstein's viscosity law. The empirical constant was based on a knowledge of the molecular weights of a variety of proteins as determined by the oil turbine ultracentrifuge. The value of k at 20° C. calculated from theory was $6{\cdot}16 \times 10^{-16}$. It was further pointed out that the discrepancy between the theoretical and empirical values disappears when the numerical in Einstein's equation was increased from 2·5 to 3·24. It is now generally accepted that the molecular weights of the proteins as determined with the oil turbine ultracentrifuge are approximately 10 per cent higher than the true values on account of faulty registration of the rotor temperature during operation of the oil turbine centrifuge[6]. This implies that the figure 3·24 must be reduced to approximately 2·92 for equation (1) to fit the new values of the molecular weights.

Recently Broersma[7] has re-examined the Einstein viscosity equation theoretically and found that the numerical 2·5 must be multiplied by a factor of 1·2 when applied to colloidal suspensions. The new numerical in Einstein's viscosity equation therefore becomes 3·0, which is in close agreement with the empirical value of 2·92. On introducing this new value into the equation, the viscosity increment of a protein at 20° C. should be truly presented by the equation:

$$[\eta] = \frac{7{\cdot}39 \times 10^{-16}}{MD^3}$$

This equation is free from empirical factors, and it offers a means of molecular weight determination without a knowledge of the partial specific volume of the substance under investigation, as is essential in the ultracentrifugation method.

[1] Longsworth, G. L., *J. Amer. Chem. Soc.*, **75**, 5705 (1953).
[2] Svedberg, T., and Pedersen, K. O., "Die Ultracentrifuge" (Theodor Steinkopf, Dresden, 1940).
[3] Polson, A., *Kolloid Z.*, **88**, 51 (1939).
[4] Polson, A., *Biochim. Biophys. Acta*, **21**, 185 (1956).
[5] Brohult, S., Dissertation Uppsala (1940).
[6] Shulman, S., *Arch. Biochem. Biophys.*, **44**, 230 (1953).
[7] Broersma, S., *J. Chem. Phys.*, **28**, 1158 (1958).

AMINO-ACID SEQUENCE OF HUMAN INSULIN

By Dr. D. S. H. W. NICOL* and Dr. L. F. SMITH†

Department of Biochemistry, University of Cambridge

THE amino-acid sequences of insulins obtained from six species have previously been reported[1–4]. The only differences found were in the sequence of three amino-acids in the *A* chain at positions 8, 9 and 10, as shown in Table 1.

Insulin from several of these species has been used in the treatment of diabetes in man, and it was of interest to know what differences, if any, there were between these proteins and human insulin for which they were acting as a substitute.

Crystalline human insulin was prepared from pancreases obtained at post-mortem. Insulin from

* Beit Memorial Fellow. Fellow of Christ's College, Cambridge. Present address: Medical Department, Freetown, Sierra Leone.
† External Staff, Medical Research Council.

Table 1. The Amino-acid Sequence at Positions 8, 9, 10 of the *A* Chain of Different Species of Insulin

	8	9	10
Cattle	Ala	Ser	Val
Pig, Sperm whale	Thr	Ser	Ileu
Sei whale	Ala	Ser	Thr
Sheep	Ala	Gly	Val
Horse	Thr	Gly	Ileu

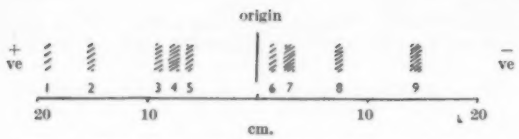


Fig. 1. Electrophoresis of pepsin digest of human faction *B*. Pyridine–acetate buffer *p*H 6·5, 30 V./cm. 1½ hr.

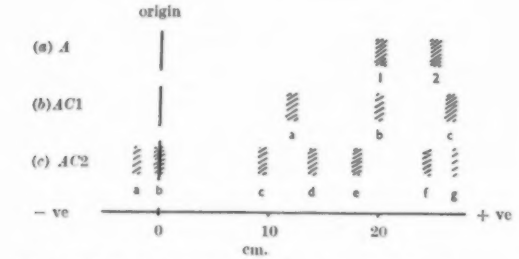


Fig. 2. Electrophoresis of enzymic digests obtained from human fraction *A*. *a*, 15 min. chymotrypsin digest of fraction *A*. *p*H 6·5, 30 V./cm. 1½ hr.; *b*, 18 hr. chymotrypsin digest of *AC*1. *p*H 6·5, 30 V./cm. 1½ hr.; *c*, 18 hr. elastase digest of *AC*2. *p*H 3·5, 30 V./cm. 1½ hr.

individual human pancreases was purified by a method to be published at a later date. Insulin was oxidized with performic acid[5] and fractionated by electrophoresis on paper at *p*H 8·9 in a 1 per cent ammonium carbonate solution.

The amino-acid sequence of fraction *B* was determined as for previous species[2,3] by digestion with pepsin at *p*H 2 and electrophoresing the digest at *p*H 6·5, giving the peptides shown in Fig. 1. An identical pattern was obtained using cattle fraction *B* as a control. Peptides 1–8 gave identical amino-acids on hydrolysis as those obtained from cattle (Table 2). Peptide 9 was different in that it contained no alanine. On treatment of this peptide with trypsin (1 per cent in 1 per cent ammonium bicarbonate, 15 min., 37° C.) followed by electrophoresis at *p*H 6·5, two bands were obtained, one of which on hydrolysis gave the same amino-acids as the parent peptide, but moved faster; the other band was free threonine. This suggested that the C terminal peptide was Tyr.Thr.Pro.Lys.Thr. This was confirmed by treatment of fraction *B* with trypsin, when the peptide Gly.Phe.Phe.Tyr.Thr.Pro.Lys, and free threonine were obtained.

Table 2. Peptides from a Pepsin Digest of Human Fraction *B*

Band (Fig. 1)	Peptide
1	Val.Glu.Ala.
2	Val.Glu.Ala.Leu.
3	Leu.Val.$CySO_3H$.Gly.Glu.Arg.Gly.Phe.
4	Tyr.Leu.Val.$CySO_3H$.Gly.Glu.Arg.Gly.Phe.
5	Tyr.Leu.Val.$CySO_3H$.Gly.Glu.Arg.Gly.Phe.Phe.
6	Phe.Val.Asp(NH_2).Glu(NH_2).His.Leu.$CySO_3H$.Gly.Ser.
7	Mixture of neutral peptides and amino-acids.
8	Phe.Val.Asp(NH_2).Glu(NH_2).His.Leu.$CySO_3H$.Gly.Ser.His.Leu.
9	Tyr.Thr.Pro.Lys.Thr.

Fraction *A* was digested with chymotrypsin (1 per cent in 1 per cent ammonium bicarbonate, 20 min., 37° C.) and after drying and electrophoresis at *p*H 3·5 gave the bands as shown in Fig. 2*a*. *AC*1 was eluted and hydrolysed with more chymotrypsin for 18 hr. *AC*2 was hydrolysed with elastase (1 per cent in 1 per cent ammonium carbonate 18 hr. 37° C.) and both electrophoresed at *p*H 3·5 (Fig. 2*b*, *c*). As shown in Table 3, *AC*1 *a*, *b*, *c* were identical with peptides previously obtained from all other species. The peptides obtained from *AC*2 together show that the sequence of amino-acids from A_1 to A_7 and A_{11} to A_{14} is the same as for all other species, and that in positions *A* 8, 9, 10 the sequence is Thr.Ser.Ileu. as had been found for pig and sperm whale insulin.

Table 3. Peptides from Human Fraction *A*

Band (Fig. 2*b*)	Peptide
*AC*1*a*	Glu(NH_2).Leu.Glu.Asp(NH_2).Tyr.
*AC*1*b*	Glu(NH_2).Leu.Glu.Asp(NH_2).Tyr.CySO_3H.Asp(NH_2).
*AC*1*c*	CySO_3H.Asp(NH_2).
(Fig. 2*c*)	
*AC*2*a*	Gly.Ileu.Val.Glu.Glu(NH_2).
*AC*2*b*	Tyr + Leu.
*AC*2*c*	Ser.Ileu.CySO_3H.Ser.
*AC*2*d*	Gly.Ileu.Val.Glu.Glu(NH_2).CySO_3H.CySO_3H.Thr. + Gly.Ileu.Val.Glu.Glu(NH_2).CySO_3H.CySO_3H.Thr.Ser.
*AC*2*e*	Gly.Ileu.Val.Glu.Glu(NH_2).CySO_3H.CySO_3H.Thr.Ser.Ileu. CySO_3H.Ser.
*AC*2*f*	CySO_3H.CySO_3H.Thr.Ser.Ileu.CySO_3H.Ser.
*AC*2*g*	Glu(NH_2).CySO_3H.CySO_3H.Thr.

When some confirmatory experiments were performed using a second batch of insulin extracted from ten pancreases, large amounts of the peptide Ser.Val.CySO_3H.Ser. were obtained from fraction *A* in addition to the sequences previously noted. It was also possible to isolate the peptide Tyr.Thr.Pro.Lys.Ala. from a pepsin digest of fraction *B* from this batch. These sequences are identical to those obtained from cattle insulin. Total hydrolysis of a sample of fraction *A* showed the presence of both threonine and alanine approximately in the ratio 1 : 2. This suggested that both cattle and pig sequences occurred in human insulin, and it was decided to determine if some individuals had the pig sequence and others the cattle sequence.

It has been found that fraction *A* can be isolated in a pure state from crude pancreatic extracts after oxidation, by electrophoresis in 20 per cent formic acid in which fraction *A* moves to the anode, all other material remaining at the origin or moving to the cathode. Using this method, fraction *A* was prepared from several individual pancreatic extracts. In later experiments the intact insulin was isolated in pure form, and the amino-acid sequence of both fractions *A* and *B* could be determined. Depending on the amount of material obtained (the pancreases varied from 80 to 150 gm. and the maximum quantity of insulin obtained was less than 10 mgm.) either the sequence or the amino-acid composition of fraction *A* was determined. The latter is sufficient to distinguish between pig and cattle insulin as the only residue of threonine in pig fraction *A* is replaced by alanine, which also occurs only once in cattle fraction *A*.

Twelve specimens were examined in this way, and only the Thr. Ser.Ileu. sequence was found in fraction *A*. While this does not prove that only the sequence Thr.Ser.Ileu. occurs in positions *A* 8, 9, 10 in the human population, to have obtained a sample containing about 60 per cent cattle sequence as in the second batch would suggest a high frequency of occurrence and might be expected to show up at least once in a sample of twelve individuals. The five samples of fraction *B* examined had only threonine as the C terminal amino-acid. It is suggested that this second batch was contaminated with cattle insulin, and that the amino-acid sequence of human insulin is that shown in Fig. 3.

The substitution of threonine for alanine as the C terminal amino-acid of the *B* chain occurs in a part of the molecule which has been shown to be un-

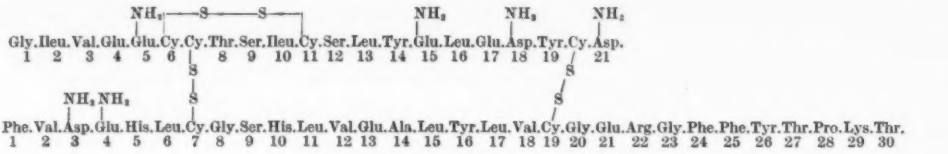

NH2 S S NH2 NH2 NH2
Gly.Ileu.Val.Glu.Glu.Cy.Cy.Thr.Ser.Ileu.Cy.Ser.Leu.Tyr.Glu.Leu.Glu.Asp.Tyr.Cy.Asp.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
S S S
NH2 NH2
Phe.Val.Asp.Glu.His.Leu.Cy.Gly.Ser.His.Leu.Val.Glu.Ala.Leu.Tyr.Leu.Val.Cy.Gly.Glu.Arg.Gly.Phe.Phe.Tyr.Thr.Pro.Lys.Thr.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Fig. 3. Structure of human insulin

essential for biological activity[6,7]. Berson and Yalow[8] demonstrated significant differences in the reaction of cattle and pig insulins with human anti-insulin serums of patients treated with mixed cattle and pig insulins. They suggested that this could be accounted for if most (or all) of the antibody produced was directed against the cattle insulin. From the close similarity of pig and human insulins, in particular the identical sequence in positions *A* 8, 9, 10, it might be expected that pig insulin would be a less-efficient producer of antibodies in man than cattle insulin.

We wish to thank Dr. F. E. Camps, Dr. D. Teare and Prof. Payling-Wright, of the University of London, for offering us facilities for obtaining the human pancreases; Dr. C. G. Pope, of the Wellcome Research Laboratories, for much assistance in extraction procedures; and Dr. F. Sanger, for encouragement and advice. One of us (D. S. H. W. N.) is indebted to the University of Cambridge for a grant from the Beebe Fund.

[1] Ryle, A. P., Sanger, F., Smith, L. F., and Kitai, R., *Biochem. J.*, **60**, 541 (1955).
[2] Brown, H., Sanger, F., and Kitai, R., *Biochem. J.*, **60**, 556 (1955).
[3] Harris, J. I., Sanger, F., and Naughton, M. A., *Arch. Biochem. and Biophys.*, **65**, 427 (1956).
[4] Ishihara, Y., Saito, T., Ito, Y., and Fujino, M., *Nature*, **181**, 1468 (1958).
[5] Hirs, C. H. W., *J. Biol. Chem.*, **219**, 611 (1956).
[6] Harris, J. I., and Li, C. H., *J. Amer. Chem. Soc.*, **74**, 2945 (1952).
[7] Nicol, D. S. H. W., *Biochem. J.*, **75**, 395 (1960).
[8] Berson, S. A., and Yalow, R. S., *J. Clin. Invest.*, **38**, 2017 (1959).

MECHANISM OF FORMALDEHYDE-INDUCED MUTAGENESIS. THE UNIQUENESS OF ADENYLIC ACID IN THE MEDIATION OF THE MUTAGENIC ACTIVITY OF FORMALDEHYDE

By Dr. THOMAS ALDERSON*
Institute of Animal Genetics, University of Edinburgh

In a previous communication[1], I have reported that in experiments using a chemically defined and axenic treatment medium, formaldehyde exhibits no mutagenic activity towards *Drosophila melanogaster* by the larval feeding method, unless ribonucleic acid is present in the treatment medium. Further analysis of this phenomenon now indicates that adenylic acid is the active component of ribonucleic acid uniquely concerned; none of the remaining nucleotides (guanylate, uridylate, cytidylate) appears to be effective. Adenylate is apparently necessary in the treatment medium for the mediation of the mutagenic activity of formaldehyde.

The indication that adenylate was the most likely nucleotide to be involved came from consideration of the patterns of utilization of the ribonucleic acid nucleotides as growth requirements in *Drosophila melanogaster* larvæ[2]. Essentially, purines and pyrimidines supplied singly cannot substitute completely for the ribonucleic acid polynucleotide, though adenylic acid, adenosine, guanylic acid, guanosine, and adenine all respectively increase growth in the order of effectiveness stated. Ribonucleic acid pyrimidine nucleosides and nucleotides supplied singly are not utilized; however, if either the pyrimidine nucleosides or nucleotides are administered simultaneously with adenylic acid, the growth-rate then obtained is indistinguishable from that with the equivalent amount of ribonucleic acid. When all the nucleotides except adenylate are supplied, growth is found to be even slower than in the absence of ribonucleic acid; however, when any of guanylate, uridylate, and cytidylate is supplied singly, but in conjunction with adenylate, the rate of growth is increased in each case. Thus, the requirement for ribonucleic acid is seen to be primarily a requirement for adenylate; and it might consequently be supposed that adenylate would be the most likely nucleotide concerned in the mediation of the mutagenic activity of formaldehyde. The following experiments were thus planned with these considerations in mind.

The design of experiments[1], the methods of treatment of larvæ[3], and the brood-pattern determination of sex-linked recessive lethal mutation-rates[3] are as previously described. The treatment medium, as previously[1], is referred to as the synthetic medium (*sm*), when ribonucleic acid is omitted; addition of nucleotides is written as $sm + a + g + u + c$, to denote the nucleotides present. The concentration of each nucleotide is taken from the equivalent amount present in 0·4 per cent ribonucleic acid, assuming the four nucleotides are found in equimolar amounts in the ribonucleic acid polynucleotide. Thus, unless otherwise stated, each nucleotide is supplied at a concentration of 0·1 per cent, which approximates closely to the optimal concentration for the purine nucleotides on the synthetic medium[2]. Ordinary medium is the yeast–maize meal–treacle medium normally used for culturing *Drosophila* in this laboratory.

Tables 1 and 2 illustrate the results obtained when larvæ are fed on *sm* + ribonucleic acid (0·4 per cent) for 15 and 18 hr. respectively, before transfer to the treatment medium for 24 hr.; after which they are allowed to complete development on ordinary food.

* Present address: Department of Genetics, University of Cambridge.

Table 1. Effect of Purine and Pyrimidine Nucleotides on the Mutagenic Activity of Formaldehyde, when 15-hr. Larvæ are treated for 24 hr.

Treatment medium	*sm*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c* delayed	*sm*+*A*+*g*+*u*+*c*
Molarity of formaldehyde	$2{\cdot}0 \times 10^{-2}$ *M*			
Total larval developmental time in days	5·5	5·0	5·5	5·0
Per cent survivors	76·6	71·0	70·0	71·6
First broods				
No. chrom.*	574	696	458	560
No. leth.	4	16	12	0
Per cent leth.	0·70	2·30	2·62	0·00
Second broods				
No. chrom.	414	363	381	371
No. leth.	0	1	2	0
Per cent leth.	0·00	0·27	0·52	0·00

* No. chrom., total number of chromosomes examined; No. leth., number of lethal chromosomes; per cent leth., percentage of sex-linked recessive lethal mutations.

Table 2. Effect of Purine and Pyrimidine Nucleotides on the Mutagenic Activity of Formaldehyde, when 18-hr. Larvæ are treated for 24 hr.

Treatment medium	*sm*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c*	*sm*+*a*+*g*+*u*+*c* delayed	*sm*+*A*+*g*+*u*+*c*
Molarity of formaldehyde	$2{\cdot}0 \times 10^{-2}$ *M*			
Total larval developmental time in days	5·5	5·0	5·5	5·0
Per cent survivors	75	80·6	53·2	70
First broods				
No. chrom.	567	565	730	577
No. leth.	2	16	10	5
Per cent leth.	0·35	2·83	1·37	0·86
Second broods				
No. chrom.	450	533	525	561
No. leth.	0	0	6	1
Per cent leth.	0·00	0·00	1·14	0·18

Since development is quicker when adenylate is present in the treatment medium, a treatment was carried out where development was slowed down on the adenylate-containing synthetic medium (*sm*+*a*+*g*+*u*+*c* delayed), to obtain a developmental time comparable with the treatment where adenylate is absent. This modification of the treatment medium has been used previously[1], and is achieved by halving the cholesterol concentration, and substituting 0·004 per cent choline for the lecithin. A treatment where 0·05 per cent adenine (*A*), which is approximately equimolar with 0·1 per cent adenylate, replaces adenylate is also listed; this treatment has the advantage that it gives a comparable developmental time with the *sm* + *a* + *g* + *u* + *c*, and the disadvantage that adenine is known to be anti-mutagenic for formaldehyde-induced mutagenesis on a yeast–glucose medium[3,4].

In both series (Tables 1 and 2), significant formaldehyde-induced mutagenic activity is found where adenylate is present in the treatment medium, whereas little or no activity is detectable in its absence. The first brood difference between *sm* + *a* + *g* + *u* + *c* and *sm* + *a* + *g* + *u* + *c* delayed is not significant in either series ($\chi^2 = 0{\cdot}12$ and 3·46, with 1 d.f., respectively), but whereas the second brood difference in Table 1 is not significant ($\chi^2 = 0{\cdot}29$, with 1 d.f.), the second brood difference in Table 2 is significant ($\chi^2 = 6{\cdot}13$, with 1 d.f.). However, if the two broods of Table 2 are summated, giving mutation-rates over the two broods of 1·45 per cent for *sm* + *a* + *g* + *u* + *c* and 1·27 per cent for *sm* + *a* + *g* + *u* + *c* delayed, the mutational response is approximately equal ($\chi^2 = 0{\cdot}145$, with 1 d.f.). This slight shift in brood patterns, where a decrease in the first brood response is followed by a corresponding increase in the second brood response, is usually characteristic of the presence of a slightly more advanced germ-tract during the period of treatment. This tendency is not expected after 'delayed' treatment, though it sometimes occurs (Table 2). A slight trend in this direction is also found in some 'delayed' treatments on a medium containing ribonucleic acid. Adenine, although giving a comparable developmental time with the *sm* + *a* + *g* + *u* + *c*, shows little or no effect, in keeping with its property as an anti-mutagen for formaldehyde-induced mutagenesis.

A further experiment, which was carried out together with one of the ribonucleic acid series[1], is illustrated in Table 3. Here, the mutagenic activity of formaldehyde was studied by treating 24-hr. larvæ for 24 hr. on *sm*, *sm*+ribonucleic acid, and *sm*+*a*+*c*; in the latter treatment, cytidylate was added at a concentration of 0·025 per cent, since the *Drosophila* Oregon-*K* stock used has a partial requirement for cytidylate[5]. As seen, adenylate is as effective as ribonucleic acid in the level of formaldehyde-induced mutations produced.

It does not appear to matter whether adenylate is present as the free mononucleotide or bound in the ribonucleic acid polynucleotide. But the mutagenic activity of formaldehyde seems dependent on the presence of adenylate within the treatment medium, since feeding with ribonucleic acid before or after treatment has no effect. Adenylate, therefore, apparently functions within the treatment medium as the necessary mediating agent in formaldehyde-induced mutagenesis.

Reactivity of Ribonucleic Acid (and its Constituent Nucleotides) with Formaldehyde

It has been revealed by spectrophotometric methods[6] that formaldehyde actively combines with the amino-groups of the purines and pyrimidines of ribonucleic acid; the binding of formaldehyde by ribonucleic acid polynucleotides appears to be a specific function of the amino-groups of their bases[6,7]. This has been further demonstrated by the reactivity

Table 3. Effect of Ribonucleic Acid and Adenylic Acid on the Mutagenic Activity of Formaldehyde, when 24-hr. Larvæ are treated for 24 hr.

Treatment medium	*sm*	*sm*+*RNA* (0·4 per cent)	*sm*+*a*+*c*
Molarity of formaldehyde		$2{\cdot}0 \times 10^{-2}$ *M*	
Total larval developmental time in days	5·5	5·0	5·0
Per cent survivors	61·8	62·6	63·6
First broods			
No. chrom.	579	602	608
No. leth.	2	21	28
Per cent leth.	0·34	3·50	4·61
Second broods			
No. chrom.	412	370	421
No. leth.	1	2	4
Per cent leth.	0·24	0·54	0·95

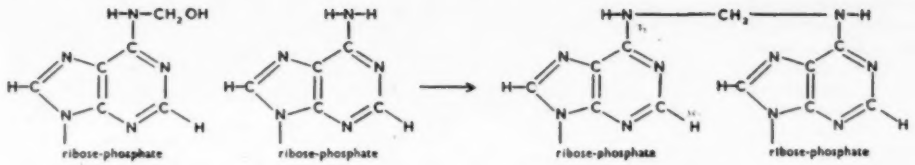


Fig. 1. Methylene bridge formation between the amino-groups of two adenylic acid molecules

of formaldehyde with various synthetic polynucleotides[7]; only polyadenylic and polycytidylic acid react readily with formaldehyde, whereas the uridylic and inosinic acid polymers do not. (The latter two polymers do not carry amino-groups.) Further, the reactivity of formaldehyde with the amino-groups of the individual ribonucleic acid mononucleotides appears to be in the preferential order of adenylate, cytidylate and guanylate[6].

Formaldehyde reacts rapidly with free amino-groups, and more slowly with hydrogen-bonded amino-groups; this difference of reaction is therefore useful for the study of hydrogen-bonding through the amino-groups of the ribonucleic acid bases. Thus, the reactivity of formaldehyde and ribonucleic acid at the two temperature-levels of 25° C. and 45° C. shows a difference in rate of 19 times; a similar experiment using an appropriate mixture of mononucleotides shows a difference in rate of only 6 times[6]. Increase of temperature, therefore, besides increasing the reactivity of formaldehyde with the free amino-groups of purines and pyrimidines, also increases the extent of its reactivity with ribonucleic acid, by freeing the hydrogen-bonds involving the amino-groups of the purine and pyrimidine bases.

The concentration of formaldehyde also undoubtedly influences the type of reaction involved[6]. It seems likely that at low (0·1 per cent) formaldehyde concentrations, formaldehyde reacts by forming the monomethylol derivative (—NH—CH_2OH); and at higher (1·0 per cent) concentrations, the dimethylol derivative (—N = $(CH_2OH)_2$). Reaction-products of formaldehyde with the amino-groups of adenylate can also be in the form of Schiff's base[6] (—N = CH_2); it is probable, however, that this grouping always involves the primary production of the monomethylol derivative.

Under the conditions of my experiments, formaldehyde is added to the treatment medium containing ribonucleic acid or adenylate at a temperature of 60° C.; considerable reaction of formaldehyde with the amino-groups of ribonucleic acid and adenylate must therefore take place. Also, since a low (0·064 per cent) formaldehyde concentration is used, a predominance of monomethylol groupings is to be expected, especially as there is a high ribonucleic acid or adenylate concentration present.

The main point of interest, however, is the possible formation of a proportion of dimeric forms, resulting in the linking together of two adenylate molecules through their amino-groups (—NH—CH_2—NH—) by a methylene-bridge, as seen in Fig. 1. This derivative is probably formed by condensation of the monomethylol grouping on the amino-group of one adenylic acid molecule with the free amino-group of another adenylic acid molecule. It has been concluded in a study of the loss of formaldehyde from ribonucleic acid after treatment with formaldehyde[7] that two forms of formaldehyde-binding occur: a labile form (probably the methylol derivative, which is relatively quickly lost); and a more stable form, with a slowly reversible binding. A larger proportion of the formaldehyde appears to be in the labile form at early stages of the reaction, whereas at later stages more stable linkages are predominant. It is suggested[7] that the stable linkages are of the dimeric form (—NH—CH_2—NH—). The ease of formation of methylene-bridges by formaldehyde after reaction with proteins has already been established[10]. This type of reaction-product (Fig. 1), which is believed to be the effective metabolite under consideration, can also be formed by polymerization from the methylene derivative (Schiff's base); in this case, a polymerization structure of indefinite length could be formed by virtue of this grouping. Additional cyclic products of the type portrayed in Fig. 2 are also possible.

For purposes of discussion, the postulated metabolite will be taken as its simplest structure, namely, two adenylic acid molecules linked together by a single methylene-bridge; this will be referred to as $\overline{AA}$. It is the thesis of this discussion that the utilization of the postulated metabolite in deoxyribonucleic acid synthesis constitutes the mechanism for its mutagenic activity.

Observations on the sensitivity pattern of response of larval germ-cells to the mutagenic activity of formaldehyde[11] suggest that the sensitive period of its activity coincides with the auxocyte stage in primary spermatocyte development, namely, the protracted growth stage which precedes meiosis in the larval testis. It is also likely that this interphase period of the auxocyte stage is the time at which deoxyribonucleic acid is being synthesized.

It will be instructive at this point to consider briefly normal synthesis of deoxyribonucleic acid and the mechanism of spontaneous mutation.

Nucleic Acid Synthesis and the Mechanism of Spontaneous Mutation

In the process of deoxyribonucleic acid replication, it is assumed that each newly synthesized deoxyribonucleic acid chain is formed along a pre-existing complementary chain, as in the model for deoxyribonucleic acid proposed by Watson and Crick[12]. In this model, specificity of replication is achieved by imposing certain restrictions on the possible pairing arrangement of the four nucleotide bases: thus, adenine can only pair with thymine; and guanine only with cytosine. Either member of a given pair can occur on either chain, but its associated partner

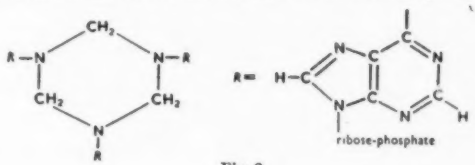


Fig. 2

on the other chain must be the other member of the pair. This restriction is made, since although the bases can exist in a number of tautomeric forms, under physiological conditions one particular tautomeride of each base is assumed to predominate (Fig. 3).

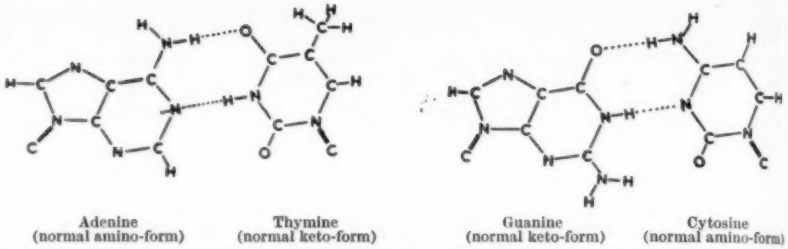


Fig. 3. Pairing of the deoxyribonucleic acid bases when present in their normal tautomeric forms. Hydrogen bonds are shown dotted. The glucosidic bond is thickly marked, and one carbon atom of the sugar is shown

Since the bases are tautomeric, however, it is possible for certain hydrogen atoms to change their positions occasionally, so that a base can exist in a rare tautomeric form. For example, adenine, in its normal amino-form, pairs with thymine; but if there is a tautomeric shift of one of its hydrogen atoms to give the imino-form, it can pair with cytosine (Fig. 4). The next time pairing occurs, the adenine (having resumed its more normal tautomeric form) will pair with thymine, and the cytosine will pair with guanine, thus resulting in a change in the sequence of bases. (A tautomeric shift in thymine whereby it can pair by mistake with guanine, and lead to a similar change in base sequence, is illustrated in Fig. 4.) This change in the sequence of bases by mistaken pairing, due to the presence of a rare tautomeride of one of the bases at the time of deoxyribonucleic acid replication, is believed to be the mechanism of spontaneous mutation[12].

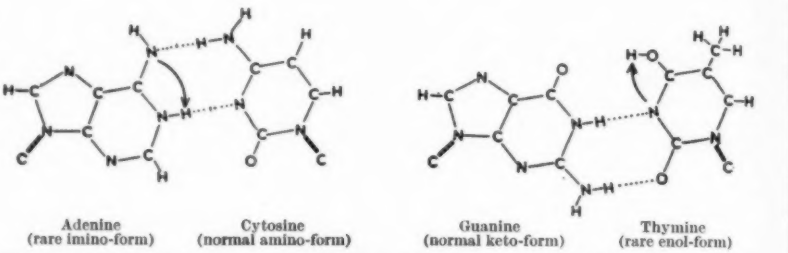


Fig. 4. Pairing of the deoxyribonucleic acid bases when a rare tautomeride of one of the bases occurs

It is now possible to consider the utilization of the postulated metabolite ($\overline{AA}$) in deoxyribonucleic acid synthesis, and the mechanism of its mutagenic activity. This metabolite possesses the correct hydrogen-bonding properties for base-pairing in the Watson and Crick model for deoxyribonucleic acid[13]; and it is interesting to note that the length of the methylene-bridge (3·7 Å.) approximates closely with the distance of 3·4 Å. between adjacent nucleotides of the same deoxyribonucleic acid chain.

Utilization of the Postulated Metabolite in Deoxyribonucleic Acid Synthesis; a Mechanism for its Mutagenic Activity

The presence of thymine (T) and cytosine (C) as adjacent nucleotides on the pre-existing deoxyribonucleic acid chain is the most obvious sequence by which the metabolite ($\overline{AA}$) could be incorporated into replicating deoxyribonucleic acid, resulting in a change in the base sequence. A prerequisite for forced pairing is that the first adenylate incorporated pairs normally, that is, with thymine; and the other adenylate, which is linked to it, thus forms a pairing mistake with cytosine. This pairing mistake could be accommodated either by tautomeric shift of one of the hydrogen atoms of the adenylate molecule (Fig. 4), or by tautomeric shift in the cytosine with which it is attempting to pair (Fig. 5). In subsequent replications, the incorporated metabolite ($\overline{AA}$) attaches to itself its normal complementary bases (TT), thus changing the original sequence, as illustrated by example in Fig. 6, from $GCATCAG$ to $GCATTAG$. Once the change in base sequence has been initiated on incorporation of $\overline{AA}$ into replicating deoxyribonucleic acid, the methylene-bridge linkage is no longer necessary, since the mistake is fixed. It should be noted that besides needing an appropriate sequence for activity, the $\overline{AA}$ metabolite could miss an opportunity to produce a change in sequence

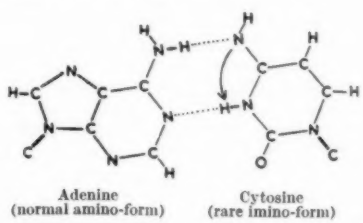


Fig. 5. Pairing between adenine and cytosine when cytosine is in its rare tautomeric form

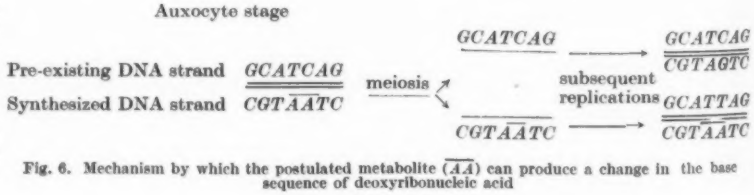


Fig. 6. Mechanism by which the postulated metabolite ($\overline{AA}$) can produce a change in the base sequence of deoxyribonucleic acid

by being initially incorporated at a *TT* sequence. Related mechanisms by which mutagenic purine and pyrimidine analogues can produce a change in the sequence of bases by their incorporation into bacteriophage deoxyribonucleic acid have been suggested by Freese[13].

During the preceding discussion, the instance where two adenylate molecules only are linked together has been considered; but larger metabolites are possible. When adenylate molecules are free in the medium, a metabolite of indefinite length could theoretically be formed. However, in the case of larger metabolites being formed by reaction of formaldehyde with ribonucleic acid, a restriction of their size would be expected, since the span of the methylene-bridge only allows linkage of adjacent adenylate molecules, which is limited by the sequence of bases along the ribonucleic acid chain. Such metabolites as are formed within ribonucleic acid would afterwards be liberated by hydrolysis of the ribonucleic acid sugar–phosphate bonds during breakdown of the ribonucleic acid into its constituent nucleotides in the gut of the larvæ; methylene-bridge linkages in proteins have been shown to be resistant to acid hydrolysis[10].

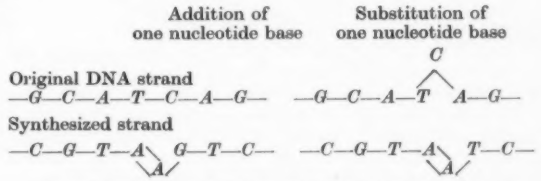
Larger metabolites are less easily incorporated into a necessary base sequence of deoxyribonucleic acid for effective utilization; for example, $\overline{AAA}$ would probably need a base sequence of *TTC*, *TCT*, or perhaps *TCC*, to initiate a change in base sequence.

In the present system, adenylate is the only ribonucleic acid base nucleotide utilized to any extent. Furthermore, as previously noted, the reactivity of formaldehyde with the amino-groups of the individual ribonucleic acid mononucleotides appears to be in the preferential order of adenylate, cytidylate and guanylate. Therefore, although other effective combinations of linked bases are theoretically possible, for example, $\overline{AC}$, $\overline{CC}$, $\overline{GG}$, and others, the $\overline{AA}$ metabolite (and perhaps an $\overline{AC}$ metabolite), would be expected to be the only significant metabolite in this system. Further, the possible utilization of a $\overline{CC}$ metabolite cannot be completely excluded in these experiments (Table 1), since the *Drosophila* stock used has a partial requirement for cytidylate[5]. Thus, the formation of appropriately linked nucleotide molecules of the type described may represent, *a priori*, a way by which specific mutagens and potential cancer chemotherapeutic agents can be constructed.

A recent investigation[14] has examined the possibilities whereby non-complementary bases can be accommodated within the two-stranded helical framework of polyribonucleotides and deoxyribonucleic acids. The authors studied the effects of varying proportions of non-complementary bases incorporated into pairs of complementary polyribonucleotides which are known to form two-stranded helices like deoxyribonucleic acid. Mixing curves were used to study the quantitative aspects of the interaction of polyadenylate (poly *A*) or polyuridylate (poly *U*) with a series of single-stranded poly *AU* copolymers. On the results of these experiments, it is concluded that non-complementary nucleotide residues in the copolymer do not remain within the helix, but loop out of the helix to allow hydrogen-bonded base pairing of subsequent regions of nucleotides which are in register. This observation is compatible with model building on the Pauling–Corey space-filling nucleotide model, where non-complementary nucleotide residues can be rotated out of the helix to allow a continuity of base pairs along its entire length. This model leaves the non-complementary base pointing radially out of the helix axis, and allows an adjacent nucleotide residue to move into the vacancy created, without stress. In addition, similar loops containing two, three or more nucleotides are also possible. In all cases, the regularity of the helix in the vicinity of the loop is unaffected, both the 3·4 Å. separation and 36° translation of successive nucleotides being maintained.

In view of the similarity of essential structure between the poly $(A + U)$ helix and deoxyribonucleic acid, it seems likely that any base pair mismatchings arising during deoxyribonucleic acid synthesis could also be accommodated by loop formation[14].

The authors discuss hypothetical models for the origin of point mutation, and, translating their models to fit the present discussion of the mutagenic mode of action of the postulated $\overline{AA}$ metabolite, the following mechanisms are suggested:



The original DNA strand remains identical in each case.

Adenine, as seen in Tables 1 and 2, has little or no capacity for mediating formaldehyde-induced mutagenesis. Formaldehyde should be able to link together two adenine molecules, in the same way as postulated for adenylate, but its free imino-group at the 9-position of the purine ring may be blocked by additional reaction with formaldehyde, thus preventing the ribose sugar attachment. This condition would be expected to debar the utilization of adenine in nucleic acid synthesis; and this is supported by the fact that I have now shown (unpublished results) that adenosine is as effective as adenylate in the mediation of formaldehyde-induced mutagenesis.

In should be noted in conclusion that the results and interpretation detailed here are entirely compatible with observations made with these test-substances on a formaldehyde-containing yeast-glucose treatment medium (unpublished work).

My acknowledgments are due to the Medical Research Council for financial support of this work, and to Prof. C. H. Waddington for supplying the laboratory facilities.

[1] Alderson, T., *Nature*, **185**, 904 (1960).
[2] Sang, J. H., *Proc. Roy. Soc. Edin.*, B, **66**, 339 (1957).
[3] Alderson, T., *Nature*, **179**, 974 (1957).
[4] Alderson, T., *Nature*, **182**, 508 (1958).
[5] Ellis, J. F., *Physiol. Zool.*, **32**, 29 (1959).
[6] Fraenkel-Conrat, H., *Biochim. Biophys. Acta*, **15**, 307 (1954).
[7] Staehelin, M., *Biochim. Biophys. Acta*, **29**, 410 (1958).
[8] Doty, P., Boedtker, H., Fresco, J. R., Haselkorn, R., and Litt, M., *Proc. U.S. Nat. Acad. Sci.*, **45**, 482 (1959).
[9] Staehelin, M., *Experientia*, **15**, 413 (1959).
[10] Fraenkel-Conrat, H., and Olcott, H. S., *J. Biol. Chem.*, **174**, 827 (1948).
[11] Auerbach, C., and Moser, H., *Z. Vererbungslehre*, **85**, 479 (1953).
[12] Watson, J. D., and Crick, F. H. C., *Cold Spring Harbor Symp. Quant. Biol.*, **18**, 123 (1953).
[13] Freese, E., *J. Molec. Biol.*, **1**, 87 (1959).
[14] Fresco, J. M., and Alberts, B. M., *Proc. U.S. Nat. Acad. Sci.*, **43**, 311 (1960).

LETTERS TO THE EDITORS

ASTRONOMY

Roughness of the Moon as a Radar Reflector

In a recent communication[1] Hughes has suggested that the law of scattering of radio waves by the lunar surface is consistent with scattering by a rough surface which has irregularities much greater than the radio wave-length, and such that the root mean square value of the slope is about 1 in 20, or 3°. The law of scattering as a function of angle of incidence which, on this model, would be the same as the distribution of the slope of the irregular surface, was found from radar observations to be given by :

$$\sigma = \sigma_0 \exp\{-10\theta\}$$

where σ is the effective scattering area and θ the angle of incidence.

It is of interest to compare this with the distribution of the slope of the lunar surface as determined optically. Fujinami, Ina and Kawai[2] have made photometric measurements of the profile of the Moon's silhouette, as observed during a partial eclipse. Measurements of the elevation of the lunar surface in seconds of arc were made for every degree around the limb. It is a simple matter to obtain a value for the slope of the lunar surface from each successive pair of readings. The distribution of these values, without regard to sign, is shown as a histogram in Fig. 1. The exponential law $\exp(-10\theta)$ is shown as a dotted line for comparison. It will be seen that there is close agreement except for angles less than 1°. (The law proposed by Hughes was stated to apply over the range 3–14°.) The root mean square value of the slope, as determined from the optical measurements, is 3·3°.

This agreement is interesting ; but it is, perhaps, surprising, because the optical measurements refer only to structure with a horizontal scale larger than about 30 km. The lunar surface could contain structure of a smaller scale, which would not be resolved optically, but which was larger than the radio wave-length. If the root mean square value of the slope of this smaller-scale structure were comparable with or larger than 3°, the overall distribution of the slope would extend to angles too large to fit the radio observations. The fact that agreement is obtained when only structure larger than 30 km. is considered suggests that the smaller structure, if it exists, has a root mean square value of slope considerably less than 3°.

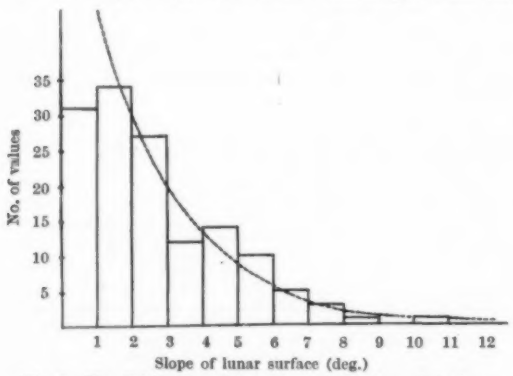


Fig. 1. The distribution of the values of the slope of the lunar surface as determined from the optical measurements of Fujinami, Ina and Kawai. The dotted line is the exponential function $\exp(-10\theta)$

B. H. Briggs

Cavendish Laboratory,
Cambridge.

[1] Hughes, V. A., *Nature*, **186**, 873 (1960).
[2] Fujinami, S., Ina, T., and Kawai, S., *Pub. Astro. Soc. Japan*, **6**, 67 (1954).

GEOPHYSICS

Evaluation of the Second, Fourth and Sixth Harmonics in the Earth's Gravitational Potential

In an article[1] in *Nature* in 1958, it was explained how the rate of rotation of the orbital plane of an Earth satellite (the rate of regression of the nodes) could be used to evaluate the even harmonics in the Earth's gravitational potential U. At an exterior point distant r from the Earth's centre and having co-latitude θ, U may be expressed in terms of Legendre polynomials P_n as :

$$U = \frac{GM}{r}\left\{1 - \sum_{n=2}^{\infty} J_n \left(\frac{R}{r}\right)^n P_n(\cos\theta)\right\} \quad (1)$$

where G is the gravitational constant, M the mass of the Earth, R its equatorial radius, and the J_n are constants to be determined. J_1 is zero if the equator is chosen to pass through the Earth's centre of mass. The motion of a satellite in the gravitational field specified by equation (1) has been investigated theoretically[2–4], and the rate of rotation of the orbital plane, $\dot{\Omega}$, may in principle be expressed in the form :

$$\dot{\Omega} = \sum_{n=2}^{\infty} J_n F_n + \sum_{m=2}^{\infty}\sum_{n=2}^{\infty} J_m J_n F_{mn} + \ldots \quad (2)$$

where the F_n and F_{mn} are functions of the orbital elements. Since J_2 is of order 10^{-3}, the J_n are of order 10^{-6} when $n > 2$, and the F_n are of the same order as the F_{mn}, only the J_2^2 term in the second series in equation (2) need be considered, and even in that term an approximate value of J_2 is adequate. Thus each observed value of $\dot{\Omega}$ provides one linear relation between the J_n, and observed values from k satellites provide k simultaneous equations between the J_n. These equations are not ill-conditioned if the k orbits differ widely enough. It happens that the odd-numbered J_n have little effect on $\dot{\Omega}$, and the available values[5] for J_3 and J_5, namely :

$$\left.\begin{aligned} J_3 &= (-2{\cdot}4 \pm 0{\cdot}3) \times 10^{-6} \\ J_5 &= (-0{\cdot}1 \pm 0{\cdot}1) \times 10^{-6} \end{aligned}\right\} \quad (3)$$

can be substituted into equation (2) without introducing significant error. Thus k satellites with widely different orbits—and, in particular, with widely differing orbital inclinations—will yield values of $J_2, J_4, \ldots J_{2k}$ if we are prepared to assume that the contributions of $J_1, J_3 \ldots$ and of $J_{2k+2}, J_{2k+4}, \ldots$ are negligible.

This process has been applied to the orbits of the satellites *Sputnik* 2 (1957β, inclination $i = 65°$), *Vanguard* 1 (1958β2, $i = 34°$) and *Explorer* 7 (1959ι1, $i = 51°$), and the following values of J_2, J_4 and J_6 have been obtained:

$$\left.\begin{aligned} J_2 &= (1082{\cdot}79 \pm 0{\cdot}15) \times 10^{-6} \\ J_4 &= (-1{\cdot}4 \pm 0{\cdot}2) \times 10^{-6} \\ J_6 &= (0{\cdot}9 \pm 0{\cdot}8) \times 10^{-6} \end{aligned}\right\} \quad (4)$$

The errors quoted are standard deviations due to observational error. In deriving these values, the effect of atmospheric rotation on $\dot{\Omega}$ and the effects of the Sun and Moon were taken into account. It is possible that errors larger than those quoted in equation (4) might be caused by the neglect of J_8, J_{10}, etc.; but it is significant that the above set of values is consistent with that derived[6] using the *Explorer* 4 satellite (1958ε) instead of *Explorer* 7, and with the values of J_2 and J_4 obtained by O'Keefe *et al.*[5] using different observational information and ignoring J_6. Thus there is reason for hoping that the errors due to the neglected higher J_n will not much exceed the errors quoted in equation (4).

If the Earth's flattening f is defined as the difference between the equatorial and polar diameters, divided by the equatorial diameter, and the meridional section is taken as elliptic, as has been customary in the past, the new value of J_2 gives $1/f = 298{\cdot}24 \pm 0{\cdot}02$, as compared with the value of 297·1 which was most generally accepted[7] before the advent of satellites.

A fuller account of this work is being published elsewhere.

D. G. King-Hele

Royal Aircraft Establishment,
Farnborough, Hants.
June 24.

[1] Merson, R. H., and King-Hele, D. G., *Nature*, **182**, 640 (1958).
[2] King-Hele, D. G., *Proc. Roy. Soc.*, A, **247**, 49 (1958).
[3] Groves, G. V., *Proc. Roy. Soc.*, A, **254**, 48 (1960).
[4] Merson, R. H., Ministry of Aviation Report (to be published).
[5] O'Keefe, J. A., Eckels, A., and Squires, R. K., *Astro. J.*, **64**, 245 (1959).
[6] King-Hele, D. G., paper presented at tenth Int. Astronautical Cong., London (1959).
[7] Jeffreys, H., "The Earth", third ed. (Camb. Univ. Press, 1952).

Oscillatory Character of Amplitude Curves for Seismic Body Waves

The importance of studying the amplitudes of seismic body waves in relation to the structure of the Earth's mantle has been emphasized by several authors[1,2]. In previous investigations[3–6], however, only general features of amplitude curves in limited distance intervals were given. Combining observations of four Middle European seismic stations—Prague, Jena, Collmberg and Potsdam—we obtained a sufficient set of homogeneous data to derive the fine structure of amplitude curves for P-, PP- and S-waves.

Maximum ground amplitudes A in μ and periods T in sec. for individual waves could be estimated by special analysis of 275 well-recorded earthquakes. Using corresponding station corrections[7], the local effects on amplitudes of body waves were eliminated. The eventual effects of the earthquake mechanism were considerably minimized by the proximity of the stations. The number of observations was as follows: 501 for *PH*, 166 for *PV*, 520 for *SH*, all in the range of 10°–100°, and 258 for *PPH* in the range of 15°–160°. Epicentral distances Δ were computed from *ISS* parameters, and from 1950 from *BCIS* or *USCGS* parameters, respectively.

Introducing:

$$A^*_i = \log A_i/T_i - M_i \quad (1)$$

for $i = PH, PV, PPH, SH$, where the magnitudes:

$$M_i = \frac{1}{n} \sum_{j=1}^{n} M j_i \quad (2)$$

for j = Prague, Jena, Collmberg, Potsdam were determined on the basis of the second approximation of the magnitude calibrating functions for body waves[7], we can take the graphical representation of the dependence (A^*_i, Δ) as the amplitude curve for the corresponding wave. The whole set of observations for an individual wave was divided into natural intervals, which were represented by their centres of gravity (large crosses in Fig. 1). Through these representative points the amplitude curve was then drafted allowing for the tendency of detailed distribution of the observations. Thus the fine structure of amplitude curves could be investigated with a considerable degree of certainty.

Two partial sections of amplitude curves with the points of observation and corresponding representative points for horizontal components of P- and PP-waves in the distance range near the '20° discontinuity' are shown in Fig. 1. The oscillatory character of the amplitude curves can be clearly seen. This

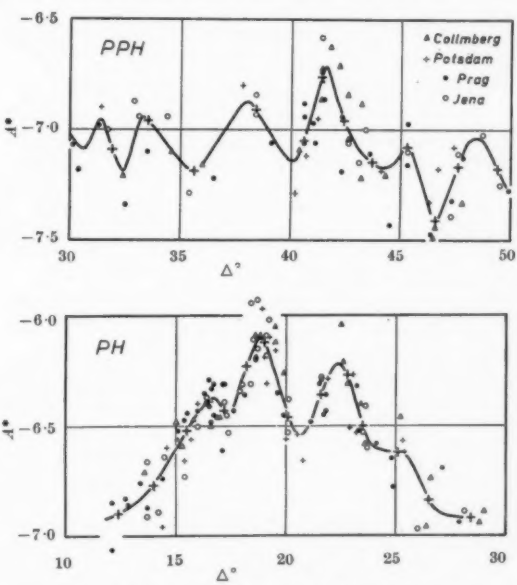


Fig. 1. Sections of amplitude curves for horizontal component of P- and PP-waves. A^*, Reduced amplitude according to equation (1); Δ, epicentral distance in degrees; large +, representative points of natural intervals

phenomenon was also found for other waves being investigated in several distance ranges.

A similar oscillatory tendency of the amplitude curve for P-waves can be observed by detailed investigation of the seismic data of underground nuclear explosions published recently[8]; the number of observations in this case, however, is insufficient for detailed conclusions. In comparison with amplitude curves reported in this communication these observations seem to show regional influences due to the probably regional structure of the upper mantle[6,9]. The oscillations observed in this distance range are evidently connected with the surface field of waves diffracted at the asthenosphere low-velocity layer[10].

A more detailed account of this work will be published in the Gerlands Beiträge zur Geophysik.

J. Vaněk*

Geophysical Institute,
Czechoslovak Academy of Sciences,
Prague.

J. Stelzner

Institut f. Bodendynamik u. Erdbebenforschung,
Deutsche Akademie der Wissenschaften,
Jena.

* Visiting assistant professor, Geophysical Institute, Karl Marx University, Leipzig.

[1] Jeffreys, H., *Mon. Not. Roy. Astro. Soc.*, Geophys. Supp., **6**, 348 (1951).
[2] Lehmann, I., *Trans. Amer. Geophys. Union*, **34**, 477 (1953).
[3] Gutenberg, B., *Bull. Seism. Soc. Amer.*, **38**, 121 (1948).
[4] De Bremaecker, J. Cl., *Bull. Seism. Soc. Amer.*, **45**, 219 (1955).
[5] Ruprechtová, L., *Studia geophys. geodaet.*, **2**, 397 (1958).
[6] Vaněk, J., *Annali di Geofisica*, **12**, 239 (1959).
[7] Vaněk, J., and Stelzner, J., *Travaux Inst. Géophys. Acad. Tchécosl. Sci.*, No. 136 (1960).
[8] Romney, C., *J. Geophys. Res.*, **64**, 1489 (1959).
[9] Dorman, J., Ewing, M., and Oliver, J., *Bull. Seism. Soc. Amer.*, **50**, 87 (1960).
[10] Ben-Menahem, A., *Bull. Seism. Soc. Amer.*, **50**, 15 (1960).

PHYSICS

Speed of the Superconducting-Normal Transition in Tin Films

We have carried out some experiments to study the rate at which resistance is restored in a superconducting tin film by the application of a magnetic field above the critical value. No direct experiment of this kind has previously been reported, although Woodford and Feucht[1], using a radiofrequency method, inferred that the transition in an evaporated film of an unspecified metal probably occurred in less than 10^{-9} sec. The question is of some importance both from a fundamental point of view and in determining the lower limit of the switching time of superconducting circuit devices such as the cryotron.

In our experiments, tin films with the characteristic 'dumb-bell' shape were evaporated on to glass slides, the central region of the films being approximately 1 cm. long, 100–400μ wide and 1000 Å. thick. The slides fitted closely into a small solenoid (1 cm. long × 0·3 cm. × 0·1 cm.) which produced a magnetic field of 29·5 œrsteds/amp. The solenoid had an inductance of 0·3 μH. and was fed through a 50 Ω coaxial cable with a rectangular current pulse which had a rise time of 10 mμsec., a length of 0·3 μsec. and a maximum amplitude of 2 amp. Experiments were normally carried out about 0·1 deg. K. below the transition temperature where the critical field was

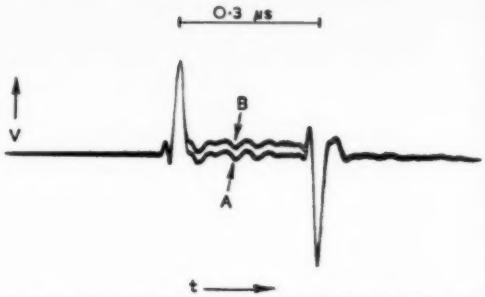


Fig. 1. Restoration of resistance in a tin film of width 250μ, thickness 1000 Å. and length 1 cm. Trace A, zero current through the film. Trace B, 1 m.amp. through the film

≃ 150 œrsteds. The pulsed field provided by the solenoid was superposed on a steady field supplied by an electromagnet. The restoration of resistance was observed by displaying on an oscilloscope, after suitable amplification, the potential difference across the film produced by a constant current, the value of this current being limited to ∼ 1 m.amp. by the Joule heating in the film while in the normal state. The normal resistance of the films was in the region of a few ohms so that the signals had an amplitude of a few millivolts.

Fig. 1 shows two superposed oscilloscope traces representing the potential difference across a typical film with and without a direct current through it. The positive and negative spikes are due to the inductive electromotive force which arises at the beginning and end of the field pulse. No delay is observable between the instant at which the pulsed magnetic field becomes constant and the restoration of resistance, and since the two traces are parallel there is no evidence of a progressive growth of resistance; there is also no evidence of any resistance remaining after the end of the pulse. This behaviour was independent of the amount by which the pulsed field exceeded the threshold value. From Fig. 1 we deduce that the transition from the superconducting to the normal state and vice versa takes place within the overall resolution of 15 mμsec., which implies that the relaxation time for the destruction of superconductivity is less than $\sim 10^{-8}$ sec. It would require a much more complicated apparatus to lower this limit significantly.

Acknowledgment is made to the Admiralty for permission to publish this communication.

D. J. Oliver
M. J. Rayner
E. H. Rhoderick

Services Electronics Research Laboratory,
Baldock, Herts.
July 1.

[1] Woodford, J. B., and Feucht, D. L., *Proc. Inst. Rad. Eng.*, **46**, 1871 (1958).

Strengths of Acid-etched Glass Rods

The low breaking strength of normal glasses is usually regarded as being due to surface imperfections, and previous workers, particularly Greene[1], have directed attention to the increase in strength which occurs when the glass surface is etched with hydrofluoric acid. By measuring the rate at which a

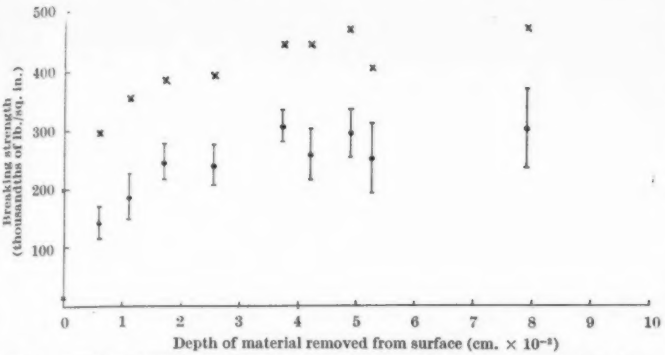


Fig. 1. Breaking strength as a function of depth of material removed from the surface. ×, Highest strength value in one group of rods; ●, mean strength and 95 per cent confidence limits for one group of rods

particular etching solution removes material from a glass surface it is possible to study the strength of etched specimens as a function of the depth of material removed from the surface. Such a study may give some information about the size and nature of the surface imperfections.

Commercially available soda-glass rods, of 6–8 mm. diameter, have been etched and broken in four point bending over a constant bending moment span of 1 in. The rod diameters and loads at fracture were measured and the breaking stresses calculated using the simple bending formula. Groups of rods (containing 16–32 rods) were given different periods of etching, and the depth of material removed from the surface of the rods was calculated for each group.

The variation of the mean breaking strength of these groups of rods, with depth of material removed from the surface, is shown in Fig. 1. Also shown on Fig. 1 are the 95 per cent confidence limits on the mean strength and the highest strength value recorded in each group of rods. Fig. 2 is a histogram comparing the distribution of breaking stresses for a group of rods which have been etched for 40 min. with that for unetched rods. The maximum strengths obtained with these bulk glass specimens are in the region 450,000–500,000 lb./sq. in. and closely approach the value obtained by Thomas[2] for fine glass fibres.

The glass rod used in these experiments had the following approximate composition by weight (percentages): SiO_2, 69; Na_2O, 16; CaO, 4; Al_2O_3, 3; MgO, 3.

The etching solution contained about 15 per cent hydrofluoric acid, 15 per cent sulphuric acid by weight and the remainder water.

Experiments are being continued to determine the effect on these results of varying the concentration, temperature and nature of the etchant; and of changing the thermal history, size and composition of the glass.

B. A. Proctor

Rolls-Royce, Ltd.,
Aerophysics Laboratory,
Littleover,
Derby.
June 22.

[1] Greene, C. H., *J. Amer. Cer. Soc.*, **39**, 66 (1956).
[2] Thomas, W. F., *Nature*, **181**, 1006 (1958); *Phys. and Chem. Glasses*, **1**, 4 (1960).

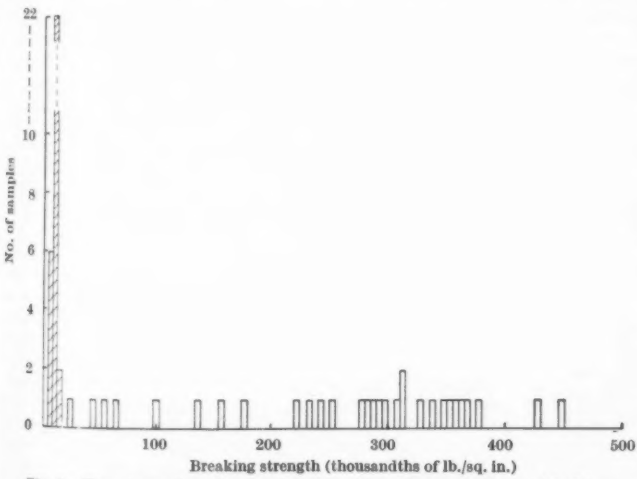


Fig. 2. Frequency of results as a function of breaking strength for etched (unshaded) and unetched (shaded) rods. The former were etched for 40 min.; depth removed from surface = $4{\cdot}2 \times 10^{-3}$ cm.

Stimulated Optical Radiation in Ruby

Schawlow and Townes[1] have proposed a technique for the generation of very monochromatic radiation in the infra-red optical region of the spectrum using an alkali vapour as the active medium. Javan[2] and Sanders[3] have discussed proposals involving electron-excited gaseous systems. In this laboratory an optical pumping technique has been successfully applied to a fluorescent solid resulting in the attainment of negative temperatures and stimulated optical emission at a wave-length of 6943 Å.; the active material used was ruby (chromium in corundum).

A simplified energy-level diagram for triply ionized chromium in this crystal is shown in Fig. 1. When this material is irradiated with energy at a wave-length of about 5500 Å., chromium ions are excited to the $^4F_2$ state and then quickly lose some of their excitation energy through non-radiative transitions to the ^2E state[4]. This state then slowly decays by spontaneously emitting a sharp doublet the components of which at 300° K. are at 6943 Å. and 6929 Å. (Fig. 2*a*). Under very intense excitation the population of this metastable state (^2E) can become greater than that of the ground-state; this is the condition for negative temperatures and consequently amplification via stimulated emission.

To demonstrate the above effect a ruby crystal of 1-cm. dimensions coated on two parallel faces with silver was irradiated by a high-power flash lamp;

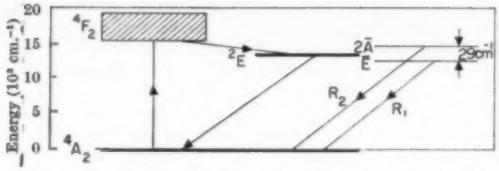


Fig. 1. Energy-level diagram of Cr^{3+} in corundum, showing pertinent processes

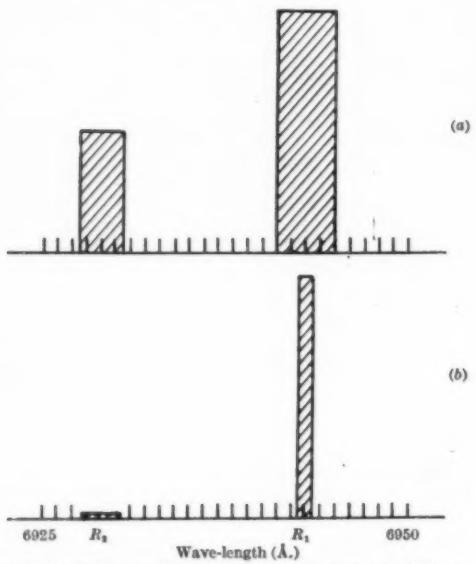


Fig. 2. Emission spectrum of ruby: *a*, low-power excitation; *b*, high-power excitation

the emission spectrum obtained under these conditions is shown in Fig. 2*b*. These results can be explained on the basis that negative temperatures were produced and regenerative amplification ensued. I expect, in principle, a considerably greater ($\sim 10^3$) reduction in line width when mode selection techniques are used[1].

I gratefully acknowledge helpful discussions with G. Birnbaum, R. W. Hellwarth, L. C. Levitt, and R. A. Satten and am indebted to I. J. D'Haenens and C. K. Asawa for technical assistance in obtaining the measurements.

T. H. Maiman

Hughes Research Laboratories,
A Division of Hughes Aircraft Co.,
Malibu, California.

[1] Schawlow, A. L., and Townes, C. H., *Phys. Rev.*, **112**, 1940 (1958).
[2] Javan, A., *Phys. Rev. Letters*, **3**, 87 (1959).
[3] Sanders, J. H., *Phys. Rev. Letters*, **3**, 86 (1959).
[4] Maiman, T. H., *Phys. Rev. Letters*, **4**, 564 (1960).

METALLURGY

A Simple Method of investigating the Creep of Metals under Simple Shear

Dr. K. H. Jolliffe and I [1] have investigated the creep of metals under simple shear by the use of a disk of the metal in question in which is cut a concentric circular annulus, the metal external to the annulus being securely gripped, while that internal to the annulus is subjected to a constant torque. We have shown that the behaviour of the metal in these circumstances is in many ways simpler and more informative than that exhibited by wires or rods under tension.

From the point of view of the industrial study of creep, the method has the disadvantage that the specimens are somewhat troublesome to prepare and measure. To get over this difficulty I have devised a method in which the specimen has the form shown in Fig. 1. In the plate *ABCD* (Fig. 1*a*) are cut rectangular grooves *MNOP*, *QRST*, as shown in cross-section in Fig. 1*b*. The metal *ABNM*, *TSCD* is securely held, and a force *F* applied to the metal *PORQ* in a direction parallel to the grooves. Under these conditions the shear stress distribution in the rectangular plates *MNOP*, *QRST* is not strictly uniform, as it is in the disk method, which is clear from the fact that the shear stress over the free ends must be zero. The distribution has been worked out by me[2] and by C. E. Inglis[3].

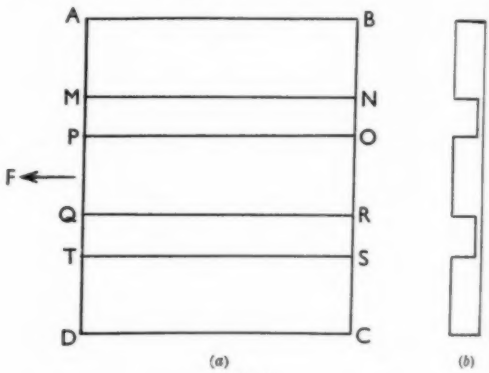


Fig. 1

Mr. D. B. Gilding has been working under my direction on the best form of the plate and has established that if the ratio of *MN* to *NO* is in the region of 7, the results on creep obtained with the disposition described correspond closely to those obtained by the method of Andrade and Jolliffe[1]. It seems possible that the new method may be of use in further investigations of creep and may also have applications to the problem of fatigue.

E. N. da C. Andrade

Department of Metallurgy,
Imperial College of Science and Technology,
London, S.W.7.

[1] Andrade, E. N. da C., and Jolliffe, K. H., *Proc. Roy. Soc.*, A, **213**, 3 (1952); **254**, 291 (1960).
[2] Andrade, E. N. da C., *Proc. Roy. Soc.*, A, **85**, 448 (1911).
[3] Inglis, C. E., *Proc. Roy. Soc.*, A, **103**, 598 (1923).

An Improvement in the Ductility of Beryllium at High Temperatures

The outstanding problem in beryllium metallurgy is the lack of ductility exhibited by the metal, both at room temperature and at elevated temperatures. At room temperature, brittleness can be attributed to the ease of cleavage of basal planes of the hexagonal lattice, and to the high yield-strength of the prismatic planes, while at temperatures above 400° C., intergranular failure predominates. A ductility maximum occurs at intermediate temperatures depending on the strain-rate used, tensile specimens failing with

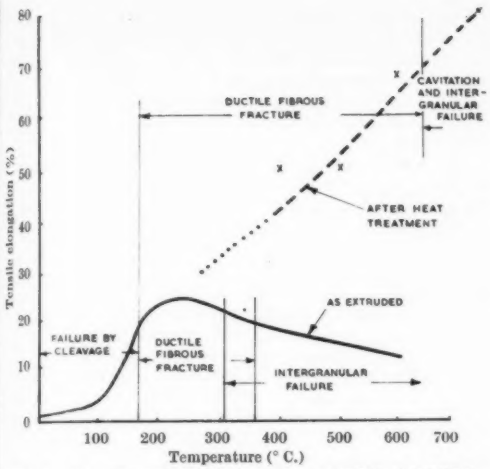


Fig. 1. Vacuum cast, pebble beryllium extruded at 1,050° C. 44 : 1 reduction

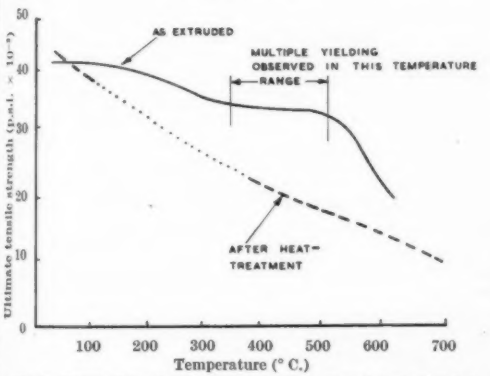

AS EXTRUDED
MULTIPLE YIELDING OBSERVED IN THIS TEMPERATURE RANGE
AFTER HEAT-TREATMENT
Ultimate tensile strength (p.s.i. × 10⁻³)
Temperature (° C.)

Fig. 2. Thermally reduced beryllium, vacuum cast and extruded at 1,050° C. 44 : 1 reduction

a ductile, fibrous fracture between 200° and 400° C. These fracture modes overlap, and two or more types of failure may be seen in any one tensile specimen.

Some increase in low-temperature ductility can be obtained by fabrication techniques which develop a texture in which the basal planes are oriented parallel to direction of working, so that loads applied in this direction exert little normal stress on basal cleavage planes. Additional resistance to cleavage is achieved by a reduction of grain size. Little has been done in the past to reduce the extent of intergranular failure, which becomes the predominant fracture mode in extruded beryllium rods as the temperature is increased above 400° C. Recent work at the Atomic Weapons Research Establishment, however, indicates that the temperature at which intergranular failure occurs can be raised by several hundred degrees by heat treating material of a suitable composition.

Fig. 1 shows the extent of the improvement in ductility that has been achieved in extruded ingot bar, fabricated from thermally reduced metal, after a heat treatment which involved heating the bar at 780° C. for 120 hr. followed by slowly cooling to room temperature over a further 120 hr. This treatment, which was insufficient to promote grain growth, apparently resulted in the precipitation of certain impurities from metastable solid solution.

Some reduction in strength also ensued from this treatment, as can be seen from a comparison of the 'as-received' and 'heat-treated' curves in Fig. 2. Of greater significance is the fact that the strength 'plateau', evident in tensile tests on the as-extruded material, between 350° and 500° C., was completely removed by the annealing treatment. This plateau was associated with multiple yielding phenomena, which can be symptomatic of the diffusion of solute impurities during the tensile test. No multiple yielding was found after the annealing treatment, and it is proposed that the solute elements concerned were precipitated, either during the treatment at 780° C. or during the subsequent equilibrium cooling. The reversibility of this precipitation treatment has been demonstrated in hot-hardness tests, re-solution appearing to occur at temperatures between 800° and 1,000° C.

The increase in ductility was associated with the disappearance of the intergranular type of failure usually inherent in beryllium at temperatures above 400° C. Comparative microstructures of the fracture modes in as-extruded and heat-treated specimens, tested at 600° C., are shown in Fig. 3.

The phenomenon was not associated merely with a softening of the matrix during annealing. A second bar of material, prepared in an identical way from purer electrolytic flake material, revealed little amelioration of tensile ductility after heat treatment as can be seen from Fig. 4. Furthermore, the hot

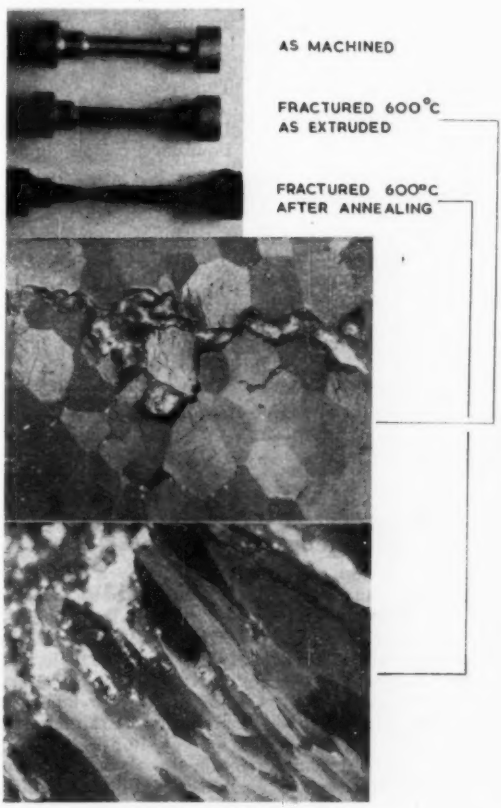


Fig. 3. (× c. 60)

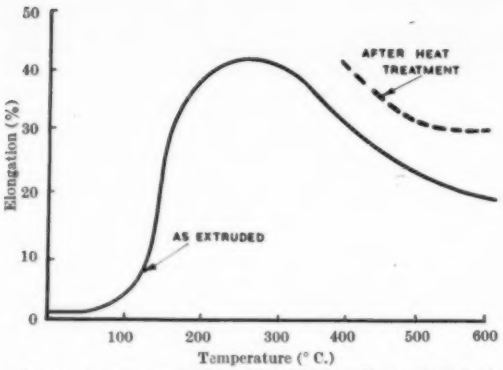


Fig. 4. Vacuum cast, electrolytic flake beryllium extruded at 1,050° C. 44 : 1 reduction

hardness characteristics of this material in the as-extruded condition were coincident with those of heat-treated thermally reduced material, and were unaffected by subsequent heat treatment. No multiple yielding was observed in this bar, even in the as-extruded state. The matrix properties of the two materials would appear to be similar after heat treatment, yet ductility is associated only with the thermally reduced material.

These, and other metallographic observations on the migration of impurities to grain boundaries in the more impure, thermally reduced metal, suggest that a specific impurity phase(s) in the more impure material artificially strengthens the boundaries at high temperatures, possibly by a keying action which prevents the boundaries shearing. This phase(s), which is either absent, or present to a smaller extent in the purer, electrolytic material, appears to migrate preferentially to the grain boundary region during the heat treatment.

This phenomenon is obviously of great importance in the metallurgy of beryllium at temperatures between 500° and 600° C., that is, within the temperature range where beryllium is to be used in nuclear reactors of the A.G.R. type, and indicates the possibility of alloying to improve the ductility at these temperatures.

A. Brown*
F. Morrow
A. J. Martin

Atomic Weapons Research Establishment,
Aldermaston.

* Attached staff from Babcock and Wilcox, Renfrew.

Hexagonal Modification of Black Chromium Electro-deposit

The formation of a hexagonal modification of an electro-deposited chromium has been discussed since the first announcement was made. In 1935, L. Wright *et al.*[1] determined the conditions for the production of the hexagonal form from chromic acid baths, and recently C. A. Snavely[2] fully examined the structural characteristics of the electro-deposited chromium from chromic acid baths containing sulphate ion.

The hexagonal modification of the black chromium electro-deposit has not been reported since the first report of black chromium was made by Siemense and Halske[3] in 1933.

The mixed crystal (hexagonal-closest-packed + body-centred cubic) was found in the black chromium electro-deposit obtained from the new bath containing chromic acid, acetic acid and urea. We were interested in this phenomenon and studied the formation of the hexagonal modification of the black chromium electro-deposit.

The baths used in this experiment were as follows: (1) chromic acid 3 *M*, acetic acid 0·05 *M* [3]; (2) chromic acid 3 *M*, acetic acid 0·05 *M*, urea 0·05 *M* [4]; (3) chromic acid 200 gm./l., glacial acetic acid 6 ml./l., nickel chloride 20 gm./l., vanadium oxide 7·1 gm./l. [5]. Precautions were taken to remove a sulphate ion contained in the chromic acid reagent. The specimens were made by electro-deposition on a copper wire at a current density of 100 amp./sq. dm. and at 15 ± 1° C. The time of electrolysis was about 3 hr. X-ray examination was made immediately after the end of electrolysis.

The X-ray diffraction analysis indicated that the structures of the electro-deposits obtained under the above conditions consisted of the mixed crystal —hexagonal - closest - packed + body - centred cube. The typical Debye–Scherrer photograph of the mixed crystals is shown in Fig. 1.

Wright *et al.*[1] stated that the factor influencing the formation of the hexagonal modification was the percentage of chromium existing in the cation in reduced chromic acid solutions. In the black chromium plating baths the mixed crystals were obtained under the conditions mentioned above in the absence of the trivalent chromium.

During the repeated electrolysis the pure hexagonal form appeared in the deposit which was electro-deposited for 14½ hr. from the bath[2] (Fig. 2).

The effects of the bath temperature, the concentration of chromic ion and urea, and the time of electrolysis on the formation of the pure hexagonal structure were examined. However, it could not be determined which factor was responsible for the formation of the pure hexagonal structure.

The change of the structure of the mixed crystal to the body-centred cubic has been reported by several authors[3,6]. In this experiment, the mixed

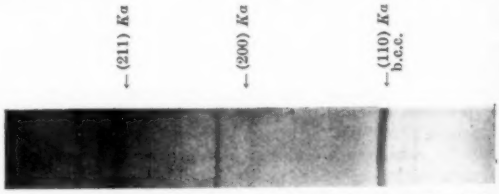


Fig. 1. Debye–Scherrer photograph (diam. 35 mm.) of the mixed crystal (h.c.p. + b.c.c.) (manganese *K* line)

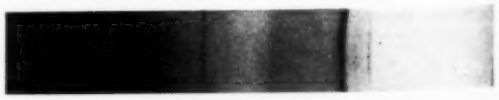


Fig. 2. Debye–Scherrer photograph (diam. 30 mm.) of the hexagonal close-packed structure (manganese *K* line)

Fig. 3. After two months from Fig. 2 (chromium *K* line, diam. 35 mm.)

crystals changed to the body-centred cubic structure from time to time. On the contrary, the pure or almost pure hexagonal crystal did not change even after two months from the end of the electrolysis (Fig. 3). When this deposit was treated in a hydrogen atmosphere at 150° C., the structure changed to the body-centred cubic crystal.

C. A. Snavely[2] thought that there is a relation between the structure of the electro-deposited chromium and the *p*H of the cathode film during electrolysis. It is suggested from the above results that the *p*H of the cathode film during the electrolysis in the black chromium baths was higher.

We wish to thank Prof. Y. Shimomura and Mr. M. Kojima for the X-ray diffraction analysis.

HIDEYA OKADA
TAKEO ISHIDA

Department of Applied Chemistry,
University of Osaka Prefecture,
Sakai City, Osaka.

[1] Wright, L., Hirst, H., and Riley, J., *Discuss. Farad. Soc.*, 1253 (1935).
[2] Snavely, C. A., *Trans. Electrochem. Soc.*, **92**, 537 (1947).
[3] Siemense and Halske, Ger. Pat. 754,360, Nov. 6, 1933.
[4] Ishida, T., Noda, Y., and Okada, H., *J. Metal Finishing Soc. Japan*, **10**, 381 (1959).
[5] Quaely, M. F., Proc. Fourteenth Ann. Conv. Amer. Electroplaters' Soc., 48 (1953).
[6] Sasaki, K., and Sekito, S., *J. Soc. Chem. Indust. Japan*, **33**, *B*, 482 (1930).

GEOLOGY

Stability of Epidote Minerals

A NUMBER of silicate minerals have proved difficult to synthesize by the commonly employed methods involving hydrothermal crystallization of glasses or reactive oxide mixes of suitable composition. Failure to synthesize a phase may be caused by the experimental conditions not being within the region where the phase is thermodynamically stable. But, in some cases, failure simply reflects a large nucleation barrier to the formation of the stable phase so that metastable phases which nucleate with ease form, and may persist indefinitely. Several workers[1–3] have considered this problem in relation to the epidote minerals, and the consistent failure of low-pressure synthesis could indicate that these phases may be stable only under relatively high-pressure conditions. Geological occurrence does not entirely support this proposition. The results presented here indicate that with these minerals nucleation is a sluggish process at low pressures, and if this step is by-passed, growth is readily achieved from the phases which normally form in synthesis. This sluggish nucleation is possibly related to the structure of the minerals.

Proof that the epidote minerals (zoisite, clinozoisite, epidote) are stable relative to the phases commonly formed in synthesis from their composition has been approached as follows. When zoisite is thermally decomposed at one atmosphere, reaction proceeds according to the reaction:

$$\underset{\text{zoisite}}{2Ca_2Al_3Si_3O_{12}(OH)} \rightarrow \underset{\text{anorthite}}{2CaAl_2Si_2O_8} + \underset{\text{wollastonite}}{CaSiO_3} + \underset{\text{gehlinite}}{CaAl_2SiO_7} + H_2O$$

Similar reactions can be written for other members of the epidote family. When zoisite synthesis is attempted at low pressures and temperatures from a mix of appropriate composition, phases on the right of the above equation tend to be formed, or if leaching of silica occurs hydrogarnets may form. In the present experiments two starting materials were used; an iron-poor clinozoisite and an epidote which, judging from refractive index, contained around 13 per cent iron sesquioxide (Fe_2O_3). These phases were first thermally decomposed to form the high-temperature assemblages and then mixtures of the epidote mineral and high-temperature products (that is, all the phases in the above equation) were sealed in small capsules with water and allowed to react for 30–80 days at 2,000 bars pressure and then examined by X-rays and microscope. With a mixture of epidote and decomposed epidote, it was found that epidote formed strongly at 505° and 630° C. while at 715° C. anorthite, garnet and magnetite were the dominant products. A mixture of clinozoisite and decomposed clinozoisite produced clinozoisite at 605° C. and anorthite and garnet (from refractive index and X-ray measurement close to grossularite) at 740° C. At 605° a few grains of garnet could be recognized, but growth of clinozoisite was spectacular. In two runs with epidote composition excess quartz was added and at 465° and 605° C. strong growth of epidote occurred.

These results indicate clearly that, relative to the normal products of synthesis, the epidote minerals are stable at moderate temperatures and water pressures. Thermodynamic consideration of entropy and changes in volume involved indicates that little pressure would be needed for their formation at low temperatures from suitable compositions. At temperatures around 300° C. and below, present results[4] indicate that zeolites will become stable. Work on other reactions involving calcium aluminosilicates in progress also demonstrates that this method of mixtures may be of value in proving relative stability of phases whenever it is suspected that the slow step in the reaction kinetics is nucleation.

This work has been supported by grants from Research Corporation and the Petroleum Research Fund, American Chemical Society.

W. S. FYFE

Geology Department,
University of California,
Berkeley.

[1] Ehlers, E. G., *J. Geol.*, **61**, 231 (1953).
[2] Goldsmith, J. R., *J. Geol.*, **61**, 439 (1953).
[3] Fyfe, W. S., Turner, F. J., and Verhoogen, J., "Metamorphic Reactions and Metamorphic Facies", Memoir 73, Geol. Soc. Amer. (1958).
[4] Coombs, D. S., Ellis, A. J., Fyfe, W. S., and Taylor, A. M., *Geochim. et Cosmochim. Acta*, **17**, 53 (1959).

Relic-Soil on Limestone in South Wales

THE Worm's Head, part of the Nature Conservancy Gower Coast National Nature Reserve, lies at the south-western tip of the Gower Peninsula of Glamorganshire, South Wales. It is a Carboniferous limestone headland accessible only at low tide across a wave-cut limestone platform. On the southern side of the Inner Head (Ord. Surv. Grid Ref. *SS* 395873) is a section in Pleistocene deposits of a type recorded widely in Gower[1–3], and elsewhere in southern Britain. This can be summarized from the base upwards as follows: (1) Wave-cut limestone platform; (2) raised beach of calcite-cemented limestone pebbles banked against solid limestone; the *Patella* beach; (3) remnants of bright red sandy clay loam, 10–18 in. thick, containing rare limestone pebbles

with red weathered outer zones; (4) brown loam containing abundant angular limestone, a periglacial head deposit. The thickness of this is variable from 0 to 10 ft.; (5) dull grey-brown stony sandy loam, glacial drift containing abundant Old Red Sandstone and Carboniferous grits and sandstones; where this is preserved on the flanks of the Worm's Head, the depth averages 4–6 ft.; (6) dull, grey-brown, sandy loam, almost stoneless, similar to the matrix of horizon 5, resting variously on horizons 2, 3 or 6.

The *Patella* beach (Horizon 2) includes fauna characteristic of a cold climate, and deposits overlying this beach elsewhere in Gower have been found to have included a fauna indicating "a climate more genial than that of the present day"[2]. Horizon 3 is interpreted here as relics of a soil which had developed on Carboniferous Limestone prior to the return of periglacial and glacial conditions responsible for Horizons 4–6.

The colour of Horizon 3 is red (Munsell colour 2.5*YR*4/6-5/8). It is sticky and mouldable when wet, moderately massive when dry. Field texture, silty loam to silty clay loam, is heavier than that given by laboratory analysis. This, by the hydrometer method, is sandy clay loam (5·5 per cent American silt, 28 per cent clay). Organic carbon content is 4 per cent and free iron oxides (by Deb's method) 3 per cent. The clay fraction minerals are dominantly illite with a minor proportion of chlorite. Thin sections reveal a skeleton of clean sub-angular quartz of mainly fine sand size in a matrix of yellow-brown colour. There are rare, small, round concretionary flecks of calcite and roughly rounded dark red-brown segregation patches of iron oxides, the latter translucent with included quartz grains. Small, round or ovoid black opaque areas, reddish-brown in reflected light, are apparently also iron oxides. Between crossed polars the clay is markedly birefringent. There are moderately well and strongly oriented coatings around sand-grains and the general clay areas are seen as fine aggregates, in the terminology of Brewer and Haldane[4]. The fabric seen in sections of this material is similar to that described in rotlehm from Cyprus[5] and in material discussed by Dalrymple[6], notably a red clay from head deposit at Slindon, Sussex. Examination of slides, including the Dalrymple material, at the Institute of Archæology, University of London (by permission of Dr. I. Cornwall), showed comparable fabric also in rotlehm from Morocco. The oriented clay is not concentrated in channels or pores, but is uniformly distributed as coatings to grains throughout the sections examined. The orientation apparently results from alternate wetting and drying of the soil-clay *in situ* rather than from illuviation of mobile clay[7]. This fabric is closely comparable to that described for terra fusca[8], a soil of braunlehm type occurring on limestone in climates of humid conditions, slightly warmer than most of Britain. The occurrence of iron segregations and of small concretions is considered a stage in the process of rubefaction[9] leading in hotter climates to a development of terra rossa from terra fusca, and rotlehm from braunlehm.

The interpretation of this material, in field morphology close to siallitic terra rossa and in micromorphology close to terra fusca, is that it is a soil of transitional character between these two sub-types. The climate for its production is likely to have been essentially similar to that of south-western Britain to-day, but with warmer summers. The shallow soils developed on limestone on the mainland cliffs adjacent to the Worm's Head show in thin section weakly developed moderately oriented coatings to sand grains, but have a higher organic matter content and well-developed crumb or granular structure. It seems that only the first stages of transition from brown earth to terra fusca have been produced as a result of post-glacial conditions in this area. A detailed study of a range of soils on limestone in Glamorgan is likely to be interesting. In particular, it is of geological and pedological significance whether the red silty clay frequently preserved over limestone in the Vale of Glamorgan and Gower is a relict material or a result of post-glacial weathering. It is suggested that it may well prove to be an interglacial relic occurring locally south of the deposits of the last glaciation.

I am grateful to Dr. D. A. Osmond for helpful discussion on this topic.

D. F. Ball

The Nature Conservancy,
Headquarters for Wales and Bangor
Research Station,
Penrhos Road,
Bangor,
Caernarvonshire.

[1] Strahan, A., "The Geology of the South Wales Coalfield". Pt. 9 (H.M.S.O., 1907).
[2] George, T. N., *Proc. Geol. Assoc.*, **43**, 4, 291 (1932).
[3] George, T. N., *Geol. Mag.*, **70**, 208 (1933).
[4] Brewer, R., and Haldane, A. D., *Soil Sci.*, **84**, 301 (1957).
[5] Osmond, D. A., and Stephen, I., *J. Soil Sci.*, **8**, 1, 19 (1957).
[6] Dalrymple, J. B., *J. Soil Sci.*, **9**, 2, 199 (1958).
[7] Stephen, I., *Science Prog.*, **48**, 322 (1960).
[8] Kubiena, W. L., "The Soils of Europe" (Murby, 1953).
[9] Kubiena, W. L., Proc. Sixth Int. Congr. Soil Sci., *E*, 347 (1956).

CRYSTALLOGRAPHY

Crystal Growth in Paraffin

An increased interest in crystallization phenomena, especially in polymeric materials, is shown by the number of publications devoted to the subject[1]. I originally published observations of crystal growth of a dislocation mechanism in polymeric material[2]; however, some observations remained unpublished and increased interest in this general area prompts this communication.

In an attempt to study growth mechanisms in polymeric material by starting with paraffin and building up to longer-chain polymers, some thought was given to how the dislocation promoting the growth is introduced. Frank[3] proposed that this dislocation is introduced into the nucleus as a result of a buckling mechanism. It was thought that this process may be checked by purposely introducing impurities to cause strain that may aid the buckling process.

Pure paraffins (hexatricontane and pentatricontane) were crystallized from solutions of petroleum ether on electron microscope grids. The resulting crystals grown were regular lozenge-shaped with dislocation spirals very clearly evident (Fig. 1). These crystals are familiar and have been previously reported by other workers[4] and are used as a standard. Into the same solutions from which these standard crystals have been grown, small amounts of 'impurity' material are added, and the new crystals grown are

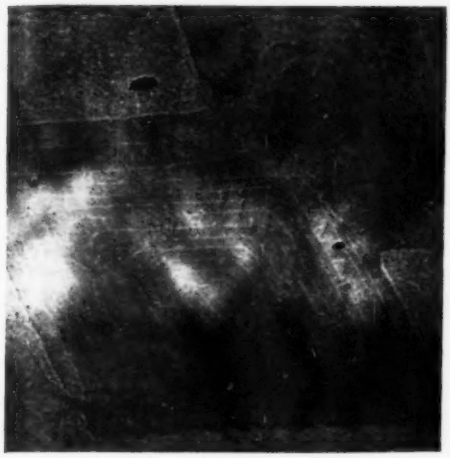


Fig. 1

Fig. 2

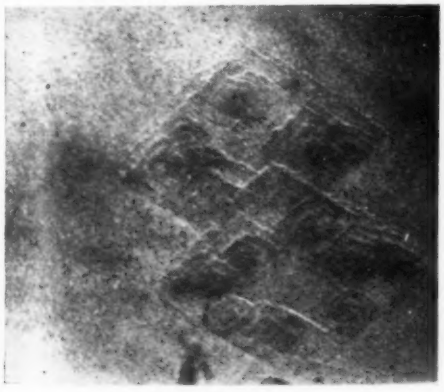


Fig. 3

examined. Impurities in the form of material with small particle sizes (dyes and colloids) were tried. None of these was successful in introducing any changes in the resulting crystals. However, small amounts of hexatricontane, either solid or from solution, when added to pentatricontane solution, and vice versa, altered the growth mechanism. The resulting crystals were changed in morphology and had many more dislocation spirals evident per growth area. (A typical example is shown in Fig. 2.) It is felt that the impurity paraffin may aid in formation of dislocations as a result of its misfit with the host paraffin.

A phenomenon of similar type may be occurring in polymeric material. Fig. 3 shows crystals grown from solution of 'Marlex No. 20' (linear polymethylene) from xylene.

R. J. Jaccodine

Bell Telephone Laboratories, Inc.,
Allentown,
Pennsylvania.

[1] "Growth and Perfection of Crystals", edit. by Doremus, R., Roberts, B. W., and Turnbull, D. (J. Wiley and Sons, New York, 1958).
[2] Jaccodine, R. J., *Nature*, **176**, 305 (1955).
[3] Frank, F. C., "Faraday Society Discussion on Crystal Growth", No. 5 (1948); *Phil. Mag.*, **42**, 1014 (1951).
[4] Dawson, I. M., and Vand, V., *Nature*, **167**, 476 (1951). Forty, A. J., "Advances in Physics", **3**, No. 9 (1954).

Five Co-ordinated Titanium in $K_2Ti_2O_5$

It is widely believed that oxygen atoms may be extracted at random from the lattices of metallic oxides, and X-ray powder photographs have suggested that little or no modification of the structure of the original stoichiometric substance occurs. In particular, evidence has been adduced that the perovskite lattice can persist between the limits ABO_3—$ABO_{2.5}$, provided that the six co-ordinated ion B is one of the metals, titanium, vanadium, cobalt or iron[1]. In order to evaluate this proposal, we are examining the crystal structures of ordered, oxygen-deficient compounds in which the ionic radii comply with the rules enunciated by Goldschmidt[2] for the perovskite structure. $K_2Ti_2O_5$ was recently reported by Schmitz-Dumont and Reckhard[3] to have a large unit cell of low symmetry, and this could, perhaps, be due to the regular omission of some of the oxygens from a perovskite lattice. We now wish to report briefly that a complete X-ray structure determination does not support this view.

Crystals of $K_2Ti_2O_5$ which are formed by slowly cooling a melt of potassium carbonate and titanium dioxide in the molar proportions 1 : 2 decompose rapidly in moist air, and require protection during X-ray exposures. They crystallize as monoclinic needles with the unit cell dimensions $a = 11{\cdot}374$, $b = 3{\cdot}799$, $c = 6{\cdot}616$ Å., $\beta = 100{\cdot}10°$, and the structure which was derived unambiguously from Patterson and Fourier projections satisfies the space-group $C2/m$. The titanium atoms are each co-ordinated to five oxygens grouped as a slightly distorted trigonal bipyramid. Two of these have an edge in common (Fig. 1), and this double unit forms an endless string elongated along y. Strings are joined to one another by having corners (oxygen atoms) in common, and this results in the formation of a two-dimensional sheet or layer of composition $(Ti_2O_5)^{2-}$. The layers are held together by the potassium atoms (Fig. 2), which have a curious unsymmetrical environment of eight oxygens, bearing only a superficial resemblance to the cubic site of the perovskite structure.

Instead of creating vacancies, the loss of some of the oxygen atoms has caused the remainder to regroup into a configuration around the titanium

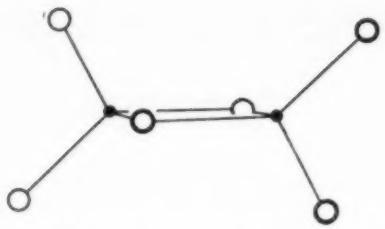


Fig. 1. Double trigonal–bipyramidal groups of oxygen (large circles) around titanium (small circles), seen in projection

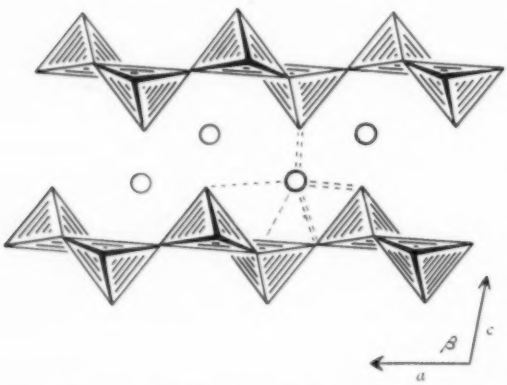


Fig. 2. Projection of the structure of $K_2Ti_2O_5$ on to (010), drawn as linked polyhedra. The potassium atoms are shown as circles, and the bonds to the nearest oxygens are drawn as broken lines for one of them

atom that is so unusual for this element that it has never, to our knowledge, been reported before. The structure of $K_2Ti_2O_5$, as a whole, has certain similarities to that of V_2O_5 in which, as in $KVO_3.H_2O$, the vanadium has five-fold co-ordination of a similar kind[4]. In the magnetoplumbite structures some of the Fe^{3+} ions also have the trigonal bipyramidal co-ordination[5]. Oxygen deficiencies in perovskites containing one or other of these cations might therefore be expected to cause, at the very least, a local rearrangement of oxygens from octahedral to trigonal bipyramidal and in this sense the term 'anion vacancy' has little real significance.

Sten Andersson*

Department of Chemistry,
University of Melbourne.

A. D. Wadsley

Division of Mineral Chemistry,
Commonwealth Scientific and Industrial
Research Organization,
Chemical Research Laboratories,
Melbourne.

* On leave from the University of Stockholm.

[1] Erchak, M., Fankuchen, I., and Ward, R., *J. Amer. Chem. Soc.*, **68**, 2085 (1946). Jonker, G. H., *Physica*, **20**, 1118 (1954). Kestigian, M., Dickenson, J. G., and Ward, R., *J. Amer. Chem. Soc.*, **79**, 5598 (1957).

[2] Goldschmidt, V. M., Barth, T., and Lunge, G., *Skr. norske Vidensk. Akad., Matem.–Naturvid. Kl.*, No. 7 (1925).

[3] Schmitz-Dumont, O., and Reckhard, H., *Monatsh. Chemie*, **90**, 134 (1959).

[4] Byström, A., Wilhelmi, K.-A., and Brotzen, O., *Acta Chem. Scand.*, **7**, 801 (1954). Christ, C. L., Clark J. R., and Evans, H. T., *Acta Cryst.*, **7**, 801 (1954).

[5] Braun, P. B., *Nature*, **170**, 708 (1952).

CHEMISTRY

Ultra-violet Absorption Spectra of the Diazines

No rotational analysis of an electronic transition has been reported for a molecule containing as many as ten atoms. However, preliminary spectrograms of pyrazine (Fig. 1) showed fine structure clearly susceptible to analysis (Fig. 2). Twelve bands which were relatively free from overlapping were photographed in the fourth order of a 150,000-line grating, and the rotational constants and accurate band centres were obtained. Similar treatment was possible for the 3200 Å. absorption of pyrimidine and the 3700 Å. absorption by pyridazine. The constants obtained for the respective 0–0 bands are:

	ν_0	$\bar{B}_0'' = \frac{A_0'' + B_0''}{2}$	$\bar{B}_0' = \frac{A_0' + B_0'}{2}$
Pyrazine	30,875·80 cm.$^{-1}$	0·2048 cm.$^{-1}$	0·2036 cm.$^{-1}$
Pyrimidine	31,072·5_2	2·205_9	0·204_1
Pyridazine	26,648·75	0·2034	2·2030

Resolved perpendicular structure of a hybrid band of pyridazine (Fig. 3) gives, from the average spacing of the P_Q branches, a very rough value for the inertial constant $(C' - \bar{B}') \simeq (C_0'' - \bar{B}_0'')$, namely, $0{\cdot}10_3$ cm.$^{-1}$. However, for each molecule, the lack of other precise data prevents determination of the geometrical structures. Parameters which give agreement with the observed $\bar{B}_0''$-value of pyrazine are shown in Fig. 1.

Since each 0–0 band is clearly of the parallel type, the electronic transition moment must in each case be parallel to the axis of largest inertia and perpendicular to the plane of the molecule.

Partial vibrational analyses have been given for the systems of pyrazine[1,2] and pyrimidine[3], but evidently not for that of pyridazine. Precise measurements of about 800 sharp Q branch edges of pyridazine, as well as of fine structures of eleven bands, have therefore been made, between 25,675 cm.$^{-1}$ and 28,775 cm.$^{-1}$. It has been possible to arrange the

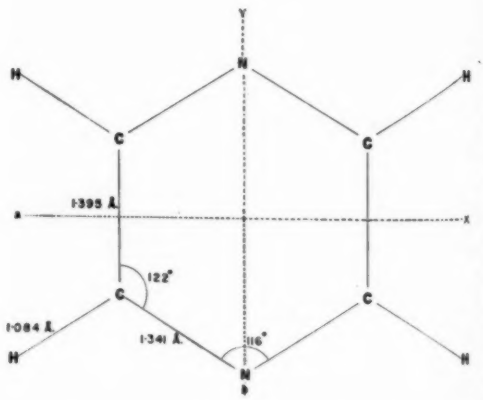


Fig. 1. Planar pyrazine (1,4 diazine). A nearly oblate symmetric top of point group D_{2h}. Note the choice of axes. Compare the point group C_{2v} for pyrimidine (1,3 diazine) and pyridazine, for each of which z is the two-fold axis and x is perpendicular to the molecular plane

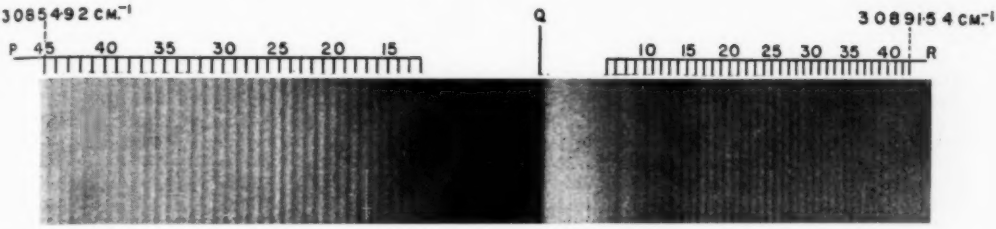


Fig. 2. 0–0 band of the λ3200 system of pyrazine. Parallel structure typical for all three molecules. The *Q*-branch edge corresponds very closely to the band centre and is sharpest for pyridazine

bands into a single band system about the origin given above. Particularly sensitive checks of the vibrational analysis were found in 'hot' bands originating in the levels 664·80 cm.$^{-1}$ (ν''_{6a}) and 969·83 cm.$^{-1}$ (ν''_1). Each of these values agrees well with the infra-red and Raman spectra of pyridazine[4] and each is observed several times in the present spectrum. Almost all the bands are degraded slightly toward longer wave-lengths, but a weaker system of blue-degraded bands was found to originate at 27,182·8$_4$ cm.$^{-1}$ (Fig. 3) and could be included in the stronger system if it was assumed that the 534·0$_9$ cm.$^{-1}$ separation from the 0–0 band represents ν'_{6b}, a ring-stretching frequency of symmetry B_1. The assignment was confirmed by observation of the (0–1) and (1–1) bands of the same vibration and by observation of the perpendicular structure of Fig. 3. The most striking feature of the vibrational analysis is the decrease of ν_{6a} from 664·80 to 372·71 cm.$^{-1}$, but two other ground-state frequencies, ν''_{9a} = 1,153·1$_5$ cm.$^{-1}$ and ν''_{15} = 1,068·60 cm.$^{-1}$, and numerous excited-state frequencies of less-certain assignment, were also obtained. No out-of-plane vibrations are important in the spectrum, so it is concluded that the pyridazine molecule is planar in the excited electronic state, B_1.

The previous work on the vibrational assignments for pyrazine and pyrimidine has indicated that it will require more than one electronic transition per molecule to account for the observed bands. Since this was not necessary for pyridazine, it has seemed worth while to review the list of pyrazine bands given by Hirt[2] and the list of pyrimidine bands given by Uber[3]. Where available, the more accurate head measurements and band centres of the present work have been used. All the bands of pyrazine between 29,965 cm.$^{-1}$ and 32,053 cm.$^{-1}$, except the weakest,

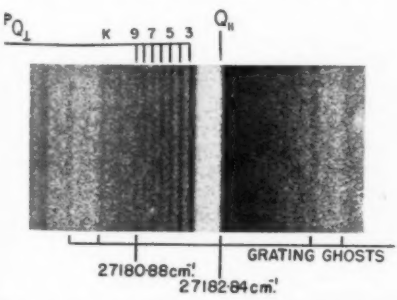


Fig. 3. Structure near the band centre of the hybrid band at 27,182·8$_4$ cm.$^{-1}$. Leading lines identify the *Q*-branch of the parallel component and several of the *PQ*-branches of the perpendicular component. On account of the slight asymmetry of the molecule, PQ_1 and PQ_2 are not observed as collected, line-like features

and all the main progressions of the pyrimidine spectrum, have been considered. Consistency with exact vibronic selection rules and with the infra-red and Raman spectra of the two molecules[4] has been imposed. A few re-assignments of the Raman spectra have been necessary. All the bands considered may be accounted for by the following fundamental vibrational frequencies and combinations of them about the respective 0–0 bands given above. For pyrazine: ν'_{6a} (A_g) = 582·61, ν''_4 (B_{2g}) = 257, ν'_4 = 477, ν''_5 (B_{2g}) = 596·06, ν'_5 = 414, ν''_{9a} (A_g) = 1,229, and ν'_{9a} = 1,106 cm.$^{-1}$. For pyrimidine: ν''_{6a} (A_1) = 679, ν'_{6a} = 530, ν''_{15a} (A_2) = 344, ν''_{12} (A_1) = 1,071, ν'_{12} = 1,015, ν''_1 (A_1) = 1,003, and ν'_1 = 1,291 cm.$^{-1}$. The reason for the prominence of non-planar vibrations, B_{2g} and A_2, in the spectra is indicated by the Franck–Condon principle: pyrazine and pyrimidine molecules are evidently slightly non-planar ('chair-form') in the excited electronic states, B_{1u} and B_1, respectively.

If the pyridazine molecule is planar in the excited state, while the related molecules are not, one may expect lower energies for excited pyridazine molecules than for excited pyrazine or pyrimidine molecules. The 4,300 cm.$^{-1}$ shift to lower energies of the pyridazine spectrum is thus readily understood. These tentative conclusions about configurations are being tested by accurate measurements of the band-heads of pyrazine and pyrimidine, by work on the dependence on temperature of each spectrum, and by examination of certain of the isotopically substituted compounds. A complete report of all this work will be published elsewhere.

This investigation was supported in part by a grant from the Petroleum Research Fund administered by the American Chemical Society, for which we are grateful. We express appreciation also for initial support by the Research Corporation and for support of the work on pyrimidine by the Office of Ordnance Research under Project No. 005-*C* of Contract *DA*-33-008-*ORD*-1780 with Vanderbilt University.

K. Keith Innes
James A. Merritt
Wayne C. Tincher
Shelby G. Tilford

Department of Chemistry,
Vanderbilt University,
Nashville
Tennessee.
Feb. 8.

[1] Ito, M., Shimada, R., Kuraishi, T., and Mizushima, W., *J. Chem. Phys.*, **26**, 1508 (1957).
[2] Hirt, R. C., *Spectrochim. Acta*, **12**, 114 (1958).
[3] Uber, F. M., *J. Chem. Phys.*, **9**, 777 (1941).
[4] Lord, R. C., Marston, A. L., and Miller, F. A., *Spectrochim. Acta*, **9**, 113 (1957).

Initial Stages of Oxidation of Coal

Our knowledge on the initial stages of oxidation of coal in air or oxygen is far from complete, though it is long known that the first stage is the formation of coal–oxygen complex and peroxygen-like bodies[1]. It is this stage and onwards where information on the mechanism of the progress of oxidation is scant. We have recently found that in the first phase of coal oxidation dehydrogenation appears to be the main reaction, without any drastic destruction of the carbon structure of coal.

Earlier[2,3] it was shown that prolonged oxidation of coal at temperatures ranging from 170° C. to 220° C. leads to preferential oxidation of the non-aromatic part leaving the aromatic nucleus unaffected, and therefrom structural parameters of coal were deduced[4–7]. The same mode of oxidation at 170° C. in air has been adopted to follow up the initial chemical changes in case of high-rank vitrain. Samples of oxidized coal were drawn at small intervals of time at the initial stages. The material balance, ultimate analysis and functional group analysis, including methyl group estimation, were done for all these oxidized samples, and the results are given in Table 1. The input and output of carbon and hydrogen before and after oxidation at different stages are also shown.

The elemental balance indicates that dehydrogenation is the main reaction at the initial stages, the loss of carbon being comparatively small.

The nature of this dehydrogenation has been studied by treating the oxidized samples with sulphur[8]. It will be seen (Table 2) that the amenability to further dehydrogenation with sulphur[8] (Vesterberg's) progressively decreases with oxidation.

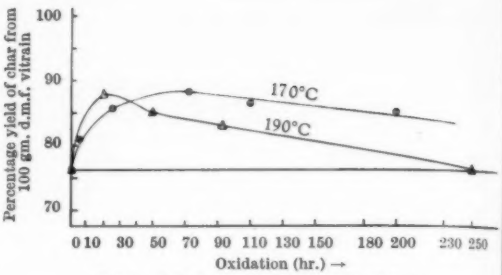


Fig. 1. Effect of oxidation on yield of char

The parallelism between the action of sulphur[8] and oxygen/air appears to be extended by the carbonization behaviour of such treated samples, for example, under both types of treatment: (1) caking property is undermined; (2) the yield of tar is inhibited; (3) the char yield increases, apparently, at the expense of the tar-forming structures. The yield of char progressively increases with the extent of oxidation and at the 72-hr. oxidation stage the yield of 'extra' char was found to be almost the same as is obtainable[8] from carbonization of the vitrain in presence of sulphur (Table 2). It has also been found that if the oxidation is continued beyond this stage, the yield of extra char decreases (Table 2), so much so, that after a time a stage is reached where the original yield of char is restored (Fig. 1).

Though the effect of dehydrogenation caused either by air/oxygen or sulphur on the carbonization behaviour is almost the same, yet the overall reaction with sulphur and oxygen does not appear to be a complete parallel. Practically no loss of carbon occurs during sulphur dehydrogenation[8], whereas 4–5 per cent of the carbon of coal is lost during air dehydrogenation. How and whence this loss occurs during the initial stages of oxidation is not readily explicable at the moment; but the fact that the tar-forming part of carbon structure can be completely stabilized at a certain stage of coal oxidation (Table 2) would possibly indicate that the loss at this stage must not have resulted at least from the destruction of tar-forming bodies.

The above phenomenon of air dehydrogenation and its consequent effects on the carbonization behaviour have also been observed to be true at other temperatures of oxidation as well. The only difference is

Table 1. Elementary Composition and its Balance at Different Periods of Oxidation
(Calculations based on 100-gm. unit coal basis)

Sample No.	Hr. of oxidation	Elementary analysis		Group analysis				Gain in weight (per cent)	Elementary balance					
									Input		Output		Percentage of elements lost	
		C (per cent)	H (per cent)	O_{OH} (per cent)	O_{COOH} (per cent)	O_{CO}+ unaccounted (per cent)	C_{CH_3} (per cent)		C (gm.)	H (gm.)	C (gm.)	H (gm.)	C	H
	Temperature, 170° C.													
1	0	87·8	5·32	1·20	0·20	3·0	2·8	—	87·8	5·32	—	—	—	
2	5	85·2	4·79	4·51	0·94	2·0	—	1·6	87·8	5·32	86·5	4·86	1·5	8·6
3	25	82·2	4·50	3·26	0·22	6·4	—	4·6	87·8	5·32	86·0	4·71	2·1	11·5
4	72	77·1	3·67	5·28	0·82	10·8	1·7	7·8	87·8	5·32	83·1	3·96	5·4	25·6
5	200	74·4	3·38	—	—	—	—	8·1	87·8	5·32	80·4	3·65	8·4	31·4
	Temperature, 190° C.													
6	20	78·1	3·70	3·40	—	—	—	8·0	87·8	5·32	84·3	4·00	4·0	25·0

Table 2. Dehydrogenation (Vesterberg's) and Carbonization Behaviour of a Vitrain with Progressive Oxidation in Air
(Data given on the basis of 100-gm. unit vitrain)

Particulars of experiment	Dehydrogenation with sulphur at 200°–360° C. Total cadmium sulphide formed (gm.)	Gray–King carbonization assay, yield of:		
		Coke or char (gm.)	Tar (gm.)	Extra yield of char (gm.)
(1) Original vitrain	—	76·2 (coke, *C*)	12·0	—
(2) Original vitrain treated with sulphur	63·2	87·2 (char)*	nil	11·0
(3) Vitrain oxidized at 170° C.				
(i) 5 hr.	45·9	81·0 (coke, *E*)	7·1	4·8
(ii) 25 hr.	41·3	85·7 (char)	2·2	9·5
(iii) 72 hr.	31·6	88·2 (char)	nil	12·0
(iv) 200 hr.	8·1	85·1 (char)	nil	8·9
(4) Vitrain oxidized at 190° C.				
(i) 20 hr.	31·0	88·0 (char)	nil	11·8
(ii) 250 hr.	—	76·4 (char)	nil	0·2

* Sulphur-free yield.

that the higher the temperature, the shorter is the period required to cause the above chemical changes. The rate of this oxidative dehydrogenation reaction has also been found to be approximately doubled for each 10° C. rise in temperature (Table 1).

The inhibition of the tar formation on oxidation of coal has been common knowledge for a long time, but the causes of its inhibition at the initial stages of oxidation now have become evident from our work. The decrease or the complete inhibition of the formation of tar is not due to the destruction of tar-forming bodies, but apparently to their re-organization. Further, these findings on the initial stages of oxidation, *vis-à-vis* the action of sulphur[8] on coal, obviously raise some pertinent questions relating to the peripheral structure of coal which will be dealt with elsewhere.

S. K. Chakrabartty
B. K. Mazumdar
A. Lahiri

Central Fuel Research Institute,
Jealgora, Bihar, India.

[1] Jones, R. P., and Townend, D. T. A., *Trans. Farad. Soc.*, **42**, 297 (1946).
[2] Mazumdar, B. K., Anand, K. S., Roy, S. N., and Lahiri, A., *Brennst.-Chemie*, **38**, 305 (1957).
[3] Mazumdar, B. K., Chakrabartty, S. K., Saha, M., Anand, K. S., and Lahiri, A., *Fuel*, **38**, 469 (1959).
[4] Mazumdar, B. K., Chakrabartty, S. K., and Lahiri, A., *J. Sci. Indust. Res.*, **16**, B, 275 (1957).
[5] Mazumdar, B. K., and Lahiri, A., *Fuel*, **37**, 495 (1958).
[6] Chakrabartty, S. K., Mazumdar, B. K., and Lahiri, A., *Fuel*, **37**, 498 (1959).
[7] Chakrabartty, S. K., Mazumdar, B. K., Roy, S. N., and Lahiri, A., *Brennst.-Chemie*, **41**, 5, 138 (1960).
[8] Mazumdar, B. K., Choudhury, S. S., Chakrabartty, S. K., and Lahiri, A., *J. Sci. Indust. Res.*, **19**, *B*, 509 (1958). Mazumdar, B. K., Chakrabartty, S. K., Choudhury, S. S., and Lahiri, A., Symp. Proc. Nature of Coal, Central Fuel Research Institute, India, Feb. 1959, 219.

Simultaneous Measurement of Adsorption and Electrodekinetic Parameters at Metal Surfaces

A recent communication by Blomgren and Bockris[1] described a radiochemical technique for the measurement of adsorption on metal surfaces, the metal being deposited on the mica window of a gas proportional counter. The metallized window serves as an electrode at which adsorption and the usual electrodekinetic parameters may be measured simultaneously. An obvious disadvantage of the above method, the introduction of a counter into an electrolytic cell, has been avoided by a technique developed in this Laboratory for the study of the poisoning by antimony of the hydrogen evolution reaction on nickel. The method employs radioactive adsorbates in conjunction with the 'transparent-cathode' technique of Joliot[2]. The latter required modification in detail but not in principle.

The technical problem was to find a simple method of placing a thin metal window on a glass vessel in such a way as to obtain a water-tight seal without introducing any source of impurity into the cell. It was found that the desired result could be obtained by holding annealed gold foil against a heavy, polished lip of a circular aperture by mechanical means only. A cross-section through such an aperture in the base of a spherical 'Pyrex' flask is shown in Fig. 1*a*. The foil (nickel-plated in this case) is held in a nickel 'holder' (hatched region) in which it had previously been annealed. The holder is shown in plan in

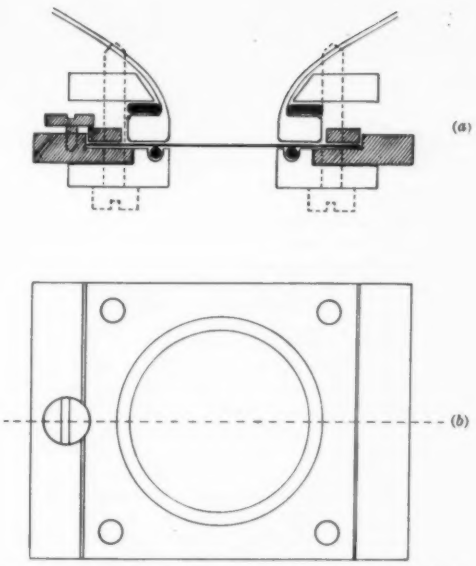


Fig. 1. *a*, Gold-foil window clamped in position; *b*, nickel holder for annealing foil

Fig. 1*b*, the cross-section shown in (*a*) being taken through the dotted line. The upper and lower parts of the brass clamp, Fig. 1*a*, are held together by four bolts threaded into the upper, horse-shoe shaped, part. The foil is placed directly against the polished glass lip and the mechanical pressure is transmitted through a rubber washer and a rubber ring, shown in solid black cross-section. The foil used in the present work was 1/100 mm. thick and supported readily 50 cm. of water on an unsupported area of 2 cm.^{2}. Thinner foil could undoubtedly be used, if it can be found free from pin-holes.

The above device permits simultaneous measurement of over-potential and amount of radiopoison adsorbed on the electrode. Some typical results are shown in Fig 2, for the poisoning by antimony of cathodic hydrogen evolution on electrodeposited nickel in 0·1 *N* sulphuric acid solution. The solution had been purified by pre-electrolysis before coming into contact with the nickel-plated foil. Fig. 2 shows the increase in cathodic overpotential for a given current (5×10^{-5} amp.cm.$^{-2}$) as a function of the amount of antimony (marked with antimony-124) adsorbed on the cathode. It was shown experimentally that the background due to antimony-124

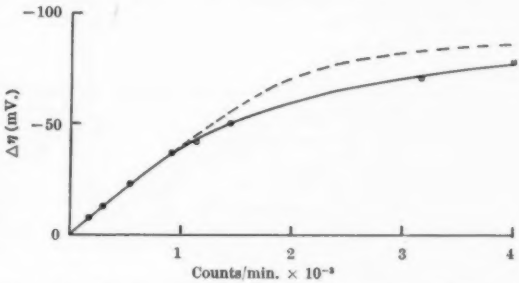


Fig. 2. Variation of over-voltage with amount of antimony adsorbed; – – –, theoretical; ——, experimental

dispersed in solution (400 ml.) was negligible. The theoretical curve, Fig. 2, was made to coincide with the initial part of the experimental curve by assuming that one atom of antimony deposited on a pure nickel surface alters the hydrogen-evolution characteristics of $2{\cdot}6\gamma$ surface nickel atoms, where $\gamma \geqslant 1$ is the surface roughness factor. Experimental details and theory will be given elsewhere.

A. M. Peers

Laboratoire Curie,
Institut du Radium,
11 Rue Pierre-Curie, Paris, 5.

[1] Blomgren, E. A., and Bockris, J. O'M., *Nature*, **186**, 305 (1960).
[2] Joliot, F., *J. Chim. Phys.*, **27**, 119 (1930).

Mr. Peers presents a solution to the technical problem of mounting a metal film in contact with a solution in such a way that cements, etc., do not cause contamination of the solution. Mr. Peers's solution of this problem is not compatible with the gradual approach of solution to the metal surface which is a characteristic feature of the method described by us. This method of gradual approach is necessary when the solution background exceeds a small fraction of the radiation from the adsorbed amount (Fig. 1 in our communication). However, Mr. Peers points out that the background from his solution was negligible compared with the activity of the adsorbed amount. Simple computation indicates that the maximum concentration of adsorbable species in the solution has to be smaller than about 10^{-6} mole $l.^{-1}$ in Mr. Peers's method. Our technique enables determinations of adsorbed amounts (with a precision of 0·1 of a monolayer) up to concentrations of adsorbate in the solution of about 10^{-3} mole $l.^{-1}$.

It may be mentioned that the problem of bringing the metal film in contact with the solution without causing contamination to the solution has also been solved by us, though in a different way from that now described by Mr. Peers. One method used by us consists in mounting the metal foil flush on a holder in such a way that the foil covers the edges and sides of the holder. Another technique consists of evaporating a metal film on a mica foil fused to the edges of a glass cylinder which surrounds the counter, using a low-melting glass. These details were excluded from our brief communication. A full account of the results will be published elsewhere.

E. A. Blomgren
Stanford Research Institute
Southern California Laboratories,
South Pasadena, California.

J. O'M. Bockris
John Harrison Laboratory of Chemistry,
University of Pennsylvania, Philadelphia, 4.

Structure of the Trinuclear Basic Acetates

The trivalent metal ions, for example, Cr^{3+}, Fe^{3+} and Al^{3+} form a variety of basic acetates which are usually supposed to contain complex ions of the type $[M_3(Ac)_6(OH)_2]^+$ (refs. 1 and 2). In addition, a very few compounds containing only one hydroxyl group have been described[2]. The whole group of compounds is of considerable interest in view of their unusual magnetic properties[3,4].

The following are among the most significant findings of the many studies which have been reported. (1) The great majority of compounds contain six or more acetate groups for each group of three metal ions. (2) Trinuclear complexes are formed only if the complex ion can be formulated to contain either hydroxyl groups or water molecules, that is, one cannot replace 'hydroxyl' groups by halide ions. (3) Strong magnetic interactions occur between the metal ions[3,4].

Here I wish to propose a structure for the group of compounds based on the experimental evidence. First, we suppose that each metal ion is octahedrally co-ordinated by negative ions or polar molecules, for this is the only type of co-ordination known for the Cr^{3+} ion. This excludes structures related to that of the cupric acetate dimer involving direct metal-metal bonds. Next, we remember that magnetic interactions between metal atoms joined by one or two hydroxyl groups, for example, between Cr^{3+} ions, are usually weak while interactions via oxide ions are often strong[3]. Finally, we note that acetate groups often link pairs of metal atoms, as in basic beryllium and zinc acetates[5].

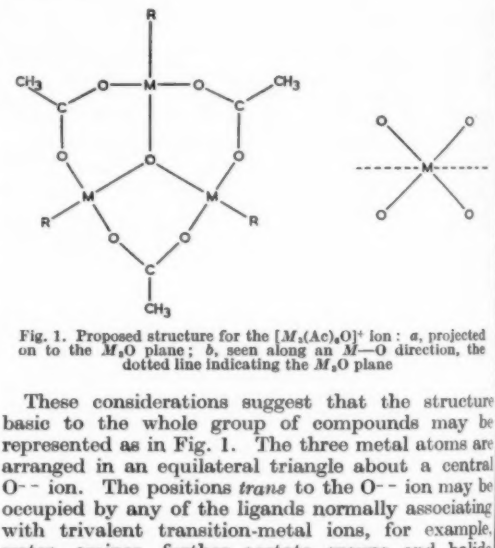


Fig. 1. Proposed structure for the $[M_3(Ac)_6O]^+$ ion: *a*, projected on to the M_3O plane; *b*, seen along an M—O direction, the dotted line indicating the M_3O plane

These considerations suggest that the structure basic to the whole group of compounds may be represented as in Fig. 1. The three metal atoms are arranged in an equilateral triangle about a central O^{--} ion. The positions *trans* to the O^{--} ion may be occupied by any of the ligands normally associating with trivalent transition-metal ions, for example, water, amines, further acetate groups and halide ions. By varying these groups a variety of different complexes can be obtained. The six acetate groups complete the octahedral co-ordination about the metal ions, each one lying completely to one side of the plane of the metal ions and linking a pair of them. A simple geometrical construction shows that this structure builds very nicely if the usual bond-lengths are assumed.

The proposed structure is closely related to that of basic beryllium acetate. It differs in that the central O^{--} ion is trigonally rather than tetrahedrally co-ordinated. (Trigonally co-ordinated O^{--} ions occur in the rutile type oxides TiO_2 (ref. 6), etc.) The apparent requirement for at least one hydroxyl group in the complex is explained if it is assumed that it is really an O^{--} ion which is involved; if OH$^-$ were really present as such it is difficult to see why it should not be replaced, for example, by halide ions.

While other structures are possible, for example, the metal ions might lie at the vertices of an equilateral triangle with two hydroxyl groups, one above and

one below the centroid of the triangle, none builds so neatly.

L. E. Orgel

Department of Theoretical Chemistry,
University Chemical Laboratory,
Lensfield Road, Cambridge.

[1] "Gmelins Handbuch der Chemie", System No. 59 (1932).
[2] Starke, K., *J. Inorg. and Nucl. Chem.*, **13**, 254 (1960).
[3] Welo, L. A., *Phil. Mag.*, **6**, 481 (1928).
[4] Wucher, J., and Gijsman, H. M., *Physica*, **20**, 361 (1954).
[5] Wilmarth, W. K., Graff, H., and Justin, S. T., *J. Amer. Chem. Soc.*, **78**, 2683 (1956).
[6] Wells, A. F., "Structural Inorganic Chemistry", second ed. (Oxford Univ. Press, 1950).

Positions of Thorium and Uranium in the Periodic Table

Element 90 of the Periodic Table, thorium, ordinarily appears as the first element of the actinide series, appended below cerium at the bottom of Table 1. This construction gives the impression that thorium is the second member of a series starting with actinium in the scandium group, just as cerium is the second member of a series starting with lanthanum in the scandium group. From the point of view of alloying behaviour it is inconsistent to consider thorium as related to the scandium group. During the course of a continuing investigation into the alloying behaviour of scandium and titanium group elements with the platinum metals, it was noted that thorium behaves as if it were a member of the titanium group. Evidence is given in Table 1 in which the crystal structure of an intermetallic compound of composition AB_3 is identified in the usual manner by the prototype of the compound family. Crystal structure data pertaining to certain of these compounds have been published[1], and for the remainder will be published shortly.

Table 1. Crystal Structures of AB_3 Intermetallic Compounds

B element	Group IV *A* element				
	Ti	Zr	Hf	Th	U
Rh	Cu_3Au	Cu_3Au	Cu_3Au	Cu_3Au	Cu_3Au
Ir	Cu_3Au	Cu_3Au	Cu_3Au	—*	Cu_3Au
Pd	$TiNi_3$	$TiNi_3$	$TiNi_3$	$TiNi_3$	$TiNi_3$
Pt	Cu_3Au	$TiNi_3$	$TiNi_3$	$ThPt_3$	$MgCd_3$

B element	Group III *A* element				
	Sc	Y	La	Ho	Ac
Rh	Cu_3Au	—*	—*	—*	?
Ir	?	—*	—*	—*	?
Pd	Cu_3Au	Cu_3Au	Cu_3Au	Cu_3Au	?
Pt	Cu_3Au	Cu_3Au	—*	Cu_3Au	?

* No compound of AB_3 composition exists; in its place are two phases, one of which is a Laves phase, AB_2.

It is instructive to consider the series of AB_3 compounds in which the *B* element is palladium. Those compounds in which the *A* element is titanium, zirconium, hafnium, thorium or uranium all have the $TiNi_3$-type structure, but those in which the *A* element is scandium, yttrium, lanthanum or holmium have the Cu_3Au-type structure. Likewise, the elements titanium to uranium form a compound having the Cu_3Au-type structure when *B* is rhodium, but the *A* elements yttrium, lanthanum and holmium do not form any AB_3 compound with rhodium.

The recognition of the resemblance of thorium to titanium, zirconium and hafnium is not new. In fact, an older version[2] of the Periodic Table placed thorium, palladium and uranium in the titanium, vanadium and chromium groups, respectively. The evidence for such a construction was largely the crystal structure resemblance among the heavy elements.

A recent review by Makarov[3] discusses the similarity between the 5*f* elements (thorium and those following it) and elements of the titanium, vanadium and chromium groups. A major point made by Makarov is that the 5*f* elements exhibit a well-established resemblance to the titanium, vanadium and chromium group elements, but that this resemblance has been obscured by the more recent concept that the transactinium elements are characterized by the presence of electrons in the 5*f* shell. Makarov points out that the most convincing evidence for the similarity between thorium and uranium, and the titanium, vanadium and chromium group elements is the formation of continuous or extensive series of isomorphous solid solutions of β-thorium and γ-uranium with the body-centred cubic forms of titanium, zirconium, hafnium, niobium and molybdenum. It seems to me that this argument actually indicates a closer resemblance between uranium and zirconium than between uranium and molybdenum, because the extent of solid solubility is much greater in the uranium–zirconium system than in the uranium–molybdenum system. Furthermore, my newly reported results and other recent data mentioned below do not support the earlier point of view that uranium resembles the chromium group elements. I have found a compound URh_3 of Cu_3Au-type, but it has been shown[4] that there is no $MoRh_3$ compound of the Cu_3Au-type. Previous work[5] had established a compound UPd_3 of the $TiNi_3$-type, but no $MoPd_3$ (ref. 6) compound was reported.

In summary, the data on AB_3 compounds discussed above indicate that both thorium and uranium resemble the titanium group elements, and furthermore that uranium bears little resemblance to molybdenum of the chromium group. It is considered that the concept in which both thorium and uranium are members of the titanium group is not inconsistent with the 'thoride' hypothesis advanced by Zachariasen[7], according to which thorium, not actinium, is the parent element of the heavy-metal series.

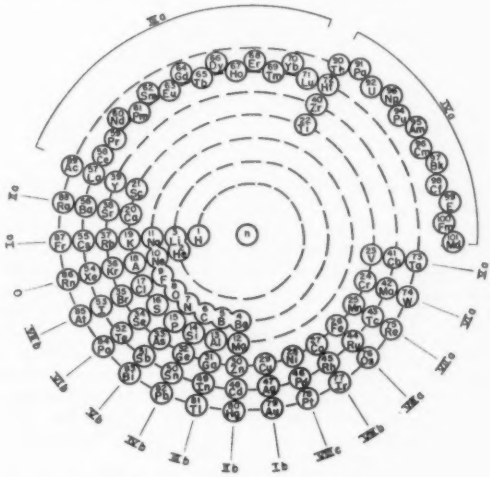


Fig. 1. Radial Periodic Table

It is thought that a Periodic Table which is realistic from the point of view of transition alloy behaviour should show thorium in a dual role, first as a member of the titanium group and secondly, as the parent of a thoride series. A possible form of such a diagram is shown in Fig. 1. There are two major advantages to this radial form of the Table. First, the lanthanide and thoride series are shown in their proper groups, rather than appended. Secondly, no implication is made that the thorides are a 'heavy rare earth' series. (It is recognized that evidence exists for considering the elements from americium on as related to the lanthinides.) An admitted disadvantage of the radial form is the dissimilarity to the familiar and useful rectangular table.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

A. E. Dwight

Argonne National Laboratory,
Argonne.

[1] Dwight, A. E., and Beck, P. A., *Trans. Amer. Inst. Mech. Eng.*, **215**, 976 (1959).
[2] Deming, H. G., "General Chemistry" as quoted in twenty-third ed., "Handbook of Chemistry and Physics" (1939).
[3] Makarov, E. S., "Crystal Chemistry of Simple Compounds of U, Th, Pu and Np" (1958).
[4] Raub, E., *Z. Metallk.*, **45**, 23 (1954).
[5] Heal, T. J., and Williams, G. I., *Acta Cryst.*, **8**, 494 (1955).
[6] Haworth, C. W., and Hume-Rothery, W., *J. Inst. Metals*, **87**, 265 (1959).
[7] Zachariasen, W. H., "Crystal Chemistry of the 5f Elements" in "The Actinide Elements", Seaborg, G. T., and Katz, J. J. (1954).

BIOCHEMISTRY

Phosphoproteins and Mitochondrial and Cell Water

In previous communications[1,2] it was shown that several antihistamine drugs in concentrations which do not affect respiration or phosphorylation reduce the rate of swelling of isolated mitochondria and also diminish the rate of extrusion of water by these particles. It was found that the drugs greatly reduce the rate of turnover of phosphoprotein phosphorus in such systems. This work has now been extended, and it has been found that a variety of agents which affect mitochondrial swelling and 'contraction' also affect the phosphorylation of proteins. A similar relation appears in liver slices taking up and extruding water under appropriate conditions. Amytal and azide inhibit mitochondrial 'contraction'[3], whereas 2,4-dinitrophenol does not. Phosphoprotein–phosphorus falls to low levels during swelling, and compounds which prevent this change preserve the phosphoproteins; this, however, might be a secondary phenomenon. During 'contraction' there is phosphorylation of protein; this is shown in Table 1, which also shows the effects of amytal, azide, 2,4-dinitrophenol and 'Phenergan', a phenothiazine antihistamine drug. It will be seen that there is a correlation between the increase in optical density of the mitochondrial suspension and the phosphorylation of protein. If the time-course of 'contraction' is followed, there is a close correlation between these two processes. Furthermore, if the mitochondria are allowed to re-swell, this event is preceded by a fall in phosphoprotein-level, even in the presence of excess adenosine triphosphate.

If liver slices are incubated anaerobically at 38° for 30 min., they take up water, which is extruded on admission of oxygen. 'Phenergan', which is known to protect liver slices from certain types of injury[4,5], inhibits this extrusion of water in much the same manner as it reduces mitochondrial 'contraction'. In Table 2 is shown an experiment with such a system. It can be seen that a diminution of extrusion of water by the drug is accompanied by failure to phosphorylate protein, though adenosine triphosphate-levels are the same as in the control. This relationship has been observed under other conditions in which extrusion of water is prevented (for example, after prolonged anoxia) even though adenosine triphosphate synthesis occurs normally. If phosphorus-32 is present in the medium, the phosphoprotein-phosphorus turns over rapidly, the specific activity of the newly formed phosphoprotein approaching that of the newly formed adenosine triphosphate within 60 min. 'Phenergan' greatly reduces the rate of turnover, but these experiments are complicated by the compartmentalization of inorganic phosphate and adenosine triphosphate within the cell. It should be noted that, under certain conditions, the antihistamine drugs will protect liver slices and permit water extrusion and potassium accumulation in circumstances in which the controls will do neither. This has been excellently demonstrated by McLean[6] for slices cut from the liver of vitamin E-deficient rats. This effect is a further complication in work with slices. It may represent protection of the phosphorylating system by inhibitor.

Table 1. Effect of Inhibitors of Mitochondrial 'Contraction' on Protein Phosphorylation

Mitochondria isolated in 0·25 *M* sucrose containing 10^{-3} *M* versene were swollen by suspension in 0·02 *M* trihydroxymethylaminomethane hydrochloride, *p*H 7·2 for 90 min. Mitochondria derived from 500 mgm. liver placed in a system containing 3×10^{-3} *M* adenosine triphosphate, 3×10^{-3} *M* manganese chloride and final volume 10 ml. Change ΔE in optical density was observed in optical cells of 1 mm. light-path. Temperature, 20°. For phosphoprotein determination the method of Schmidt and Thannhauser was adapted for estimation of small amounts of inorganic phosphate liberated from phosphoprotein by alkaline hydrolysis

Mitochondria	ΔE/20 min.	Phosphoprotein–phosphorus (μgm./gm. original liver)	ΔP
Initially swollen	—	1·84	—
Control	0·176	5·24	3·4
2,4-Dinitrophenol (10^{-4})	0·170	4·64	2·8
'Amytal' (10^{-3} *M*)	0·060	2·7	0·86
Azide (2×10^{-3} *M*)	0·013	2·20	0·36
Initially swollen	—	3·20	—
Control	0·150	6·00	2·80
'Phenergan' (10^{-4})	0·082	4·40	1·20

It may be argued that phosphoprotein-levels merely reflect adenosine triphosphate-levels, much as in the case of phosphocreatine. Against this view is the fact that there is considerable excess of adenosine triphosphate in the mitochondrial experiments. In the slice, however, such an explanation is more likely, since the levels of adenosine triphosphate and phosphoprotein are of the same order; but there is no evidence from *in vitro* studies with cell-free preparations or slices that 'Phenergan' interferes with adenosine triphosphate synthesis or turnover-rates at the concentrations used.

It is therefore suggested that there is a direct relationship between movement of water and phosphorylation of protein, both in mitochondria and in whole cells. It is also suggested that the reactions regulating these processes are:

$$\text{ATP} + \text{protein} \rightleftharpoons \text{ADP} + \text{phosphoprotein} \quad (1)$$

$$\text{ATP} \rightarrow \text{ADP} + \text{inorganic phosphate} \quad (2)$$

$$\text{phosphoprotein} \rightarrow \text{protein} + \text{inorganic phosphate} \quad (3)$$

Table 2. Effect of 'Phenergan' on Water Extrusion, Adenosine Triphosphate- and Phosphoprotein-Levels of Slices

Slices about 200 mgm. wet weight were placed in Krebs–Ringer, containing sodium bicarbonate and gassed for first 30 min. with 95 per cent nitrogen–5 per cent carbon dioxide. For aerobic recovery, the gas was 95 per cent oxygen–5 per cent carbon dioxide. Temperature, 38°. Slices were removed from vessels, blotted and weighed, then dried at 105°. For adenosine triphosphate and phosphoprotein determinations, duplicate slices were used, the whole flask contents being deproteinized and homogenized. 'Phenergan' at 10^{-4} *M* was placed in the flasks at the start of aerobic recovery

Slice	Percentage of dry weight		Adenosine triphosphate (μmoles P/gm. wet weight)		Phosphoprotein–phosphorus (μmoles P/gm. wet weight)	
	Control	10^{-4} *M* 'Phenergan'	Control	10^{-4} *M* 'Phenergan'	Control ΔP	10^{-4} *M* 'Phenergan' ΔP
Initial	28·0	—	1·7	—	1·00	—
30-min. anoxia	21·0	—	0·54	—	0·54	—
30-min. oxygen	23·0	23·0	0·87	0·72	0·76 (0·22)	0·63 (0·09)
60-min. oxygen	24·0	23·0	1·05	1·10	0·80 (0·26)	0·65 (0·11)
90-min. oxygen	25·0	23·0	1·25	1·20	0·76 (0·22)	0·65 (0·11)

All these reactions occur in liver mitochondria and slices. It is to be noted that reaction 2 will degrade phosphoprotein by causing reversal of reaction 1, and that reactions 1 and 3 together can constitute an adenosine triphosphatase. Reactions 2 and 3 will therefore act in concert to catalyse cell degradation under unfavourable conditions. Inhibition of any one of the three reactions will tend to protect. The results so far available suggest reaction 1 as the site of action of the antihistamines, but this itself may be a complex system.

Finally, 'Benadryl' and 'Phenergan' afford potent protection against mitochondrial swelling due to glutathione and much reduce the rate of swelling induced by β-hydroxybutyrate; this again suggests the attractive idea that the single mechanism underlies all these abnormal shifts of water. The importance of the system inhibited by the drugs is illustrated by the fact that they protect rats against liver injury due to thioacetamide[5] and to nutritional deficiency[6], and will also protect mice against murine hepatitis virus[7].

This work has been supported in part by United States Public Health Service grant No. *C*-4534 and by Chas. Pfizer and Company, Inc.

J. D. Judah

Wistar Institute of Anatomy and Biology,
Philadelphia, Pa.

[1] Judah, J. D., *Nature*, **185**, 390 (1960).
[2] Judah, J. D., *Exp. Cell Res.*, **19**, 404 (1960).
[3] Lehninger, A. L., *J. Biol. Chem.*, **234**, 2465 (1959).
[4] McLean, A. E. M., *Nature*, **185**, 191 (1960).
[5] Gallagher, C. H., Gupta, D. N., Judah, J. D., and Rees, K. R., *J. Path. Bact.*, **72**, 193 (1956).
[6] McLean, A. E. M., *Nature*, **185**, 936 (1960).
[7] Judah, J. D., Bjotvedt, G., and Vainio, T., *Nature* (in the press).

Protection against Liver Injury due to Murine Hepatitis Virus

Previous work has shown that antihistamine drugs protect against liver injury caused by a variety of agents[1] both in the whole animal and *in vitro*. Judah has also shown that these compounds inhibit mitochondrial swelling *in vitro*, and has indicated a possible mechanism of action[2,3]. McLean[4] has shown that the antihistamine 'Phenergan' will protect rats against nutritional liver necrosis and has demonstrated *in vitro* effects of this drug with slices cut from the livers of rats on necrogenic diets.

In the present communication, it is shown that the antihistamine drug 'Benadryl' affords significant protection to mice infected with murine hepatitis virus (MHV 3) (Dick, Niven and Gledhill[5]). In addition, mouse liver macrophages and parenchymal cells grown in organ culture (Bang and Warwick[6]) were protected by 'Benadryl' from the cytolytic effect of the hepatitis virus.

The murine hepatitis virus was obtained from Dr. Gledhill and inoculated intraperitoneally into adult *C* 57/*Bl* 6 mice in this laboratory. When these mice became ill, they were killed and their livers made into suspensions as a source of virus inoculum in subsequent experiments. The *LD*50 of virus necessary to cause deaths in the mice within 5 days was established, and it was also found that this dose killed nearly all the animals within 7 days after infection. If 'Benadryl' was administered at the same time as the virus, and a dose of 100 mgm./kgm. body-weight given daily throughout the experiment, a substantial diminution of the number of deaths was found. Table 1 shows the results of this protection experiment. On analysis, it is found that P is less than 0·001 even on the seventh day of the experiment, so that protection is highly significant. Subsidiary tests for protection were also used: thus the level of blood malic dehydrogenase was determined at intervals during such experiments (Table 2) and it was found that both 'Benadryl' and 'Phenergan' prevented the marked rise of this enzyme in the serum which is associated with liver injury.

The livers of mice treated with 'Benadryl' and of control mice were also examined histologically. The earliest change is a focal necrosis, clearly seen on the third day, but already present on the second day. This stage is indistinguishable in both groups of mice. However, by the fourth day, the control mice showed confluent areas of necrosis, all liver lobules being affected, and many completely destroyed. In contrast, the mice treated with 'Benadryl' showed very marked preservation of the liver, the lesions still retaining their focal character.

Virus concentration in the livers of treated and control mice was determined on the fourth day after

Table 1. Protection of Mice against Mouse Hepatitis Virus 3

The animals were randomly selected male *C* 57 black mice, weight. range 20–22 gm. They were inoculated intraperitoneally with 0·05 ml. of liver suspension and at the same time, where indicated, 'Benadryl' was injected subcutaneously in the appropriate dose

Treatment	No. of animals inoculated	Survivors on day: 5	6	7
Control	68	34	21	11
'Benadryl' (100 mgm./kgm.)	61	48	38	26

Table 2. Blood Serum-Levels of Malic Dehydrogenase

Treatment	No. of animals	Malic dehydrogenase, as μmoles DPN reduced/ml. serum/hr.
Controls	4	10·0 (range 7–12)
MHV 3	5	30·0 (range 23–36)
MHV 3, and treated with 'Benadryl'	5	18·0 (range 14–20)

inoculation, when mice in both groups were killed and their livers made into suspensions which were inoculated intraperitoneally, in serial dilutions, into other mice. The results revealed substantially the same concentration of virus in livers from mice treated with 'Benadryl' and control animals, which implies that the effect of the drug was to prevent necrosis of the liver cell, rather than to act directly on the virus. This is in keeping with the hypothesis[2] that the antihistamines inhibit a general mechanism of degradation.

In order to simplify the work, organ cultures of mouse liver on reconstituted collagen were infected with mouse hepatitis virus according to the technique of Bang and Warwick (whose medium was modified to contain 30 per cent of a mixture of calf serum and chick embryo extract in the proportions of 3 : 1). It was found, in keeping with their results, that macrophages are first destroyed by this virus within 24–28 hr. after infection, but that two days later lesions caused by virus also appeared in the hepatic cells, ultimately destroying the entire culture. 'Benadryl' afforded complete protection against injury to both types of cell, in concentrations of 10^{-4}–10^{-5} *M* when added at the same time as the virus. The same protection was observed by the addition of anti-mouse hepatitis virus 6 immune mouse serum, whereas normal mouse serum was without effect.

The presence of hepatitis virus in cultures was determined by inoculation of culture fluids and cells, respectively, into *C57/Bl* 6 mice. Virus was always recovered from control cultures even after several passages through mouse liver organ cultures, but culture fluids from cultures treated with 'Benadryl' showed only minimal amounts of virus. These findings are being further investigated.

It is possible that necrosis of liver cells in an animal infected with hepatitis virus is not directly caused by multiplication of the virus within the cell. 'Benadryl' prevents or delays considerably the necrosis of the cell, but has little or no effect on multiplication of the virus in liver tissue of infected animals. This is supported by the fact that the livers show the same amount of virus present in both groups of animals at the very time that histological and biochemical observations indicate a considerable reduction in the death of cells in the treated animals. This concept may undergo revision in the light of results obtained in organ cultures. However, the results also support the view of a general mechanism of liver injury. This may be taken to involve the system responsible for the maintenance of water and electrolyte balance in the whole cells and possibly the mitochondria, and the inference is supported by the work of McLean and of Judah already cited.

This work has been supported in part by United States Public Health Service grant No. *C*-4534 and by Chas. Pfizer and Co., Inc.

J. D. Judah
G. Bjotvedt
T. Vainio

Wistar Institute of Anatomy and Biology,
Philadelphia, Pa.

[1] Gallagher, C. H., Gupta, D. N., Judah, J. D., and Rees, K. R., *J. Path. Bact.*, **72**, 193 (1956).
[2] Judah, J. D., *Nature*, **185**, 390 (1960); *Exp. Cell Res.*, **19**, 404 (1960).
[3] Judah, J. D., *Nature* (preceding communication).
[4] McLean, A. E. M., *Nature*, **185**, 191 and 936 (1960).
[5] Dick, C. W. A., Niven, J. S., and Gledhill, A. W., *Brit. J. Exp. Path.*, **37**, 90 (1956).
[6] Bang, F. B., and Warwick, A., *Virology*, **9**, 716 (1959).

Selective Cytochemical Demonstration of Arginine Groups in Nucleoprotein in the Cell Nucleus

Useful information should accrue from cytochemical measurements of the arginine contained in the basic proteins linked to deoxyribonucleic acid in the nucleus. The specific Sakaguchi reaction for arginine has been modified for microspectrophotometry[1].

The main obstacles to its reliable exploitation for the purpose mentioned are: (i) the contribution of arginine groups not involved in the deoxyribonucleic acid–protein complex; (2) the stain in surrounding cytoplasm, necessitating the use of isolated nuclei, with concurrent artefacts; (3) removal of material from the specimen by the strongly alkaline reagent mixture.

We have examined the effect of prior anhydrous benzoylation[2] on this reaction, and the applicability of freeze-drying and freeze-substitution which would minimize some fixation artefacts[3]. Benzoyl chloride reacts at cytoplasmic protein groups but leaves certain nuclear groups unblocked[2,4].

We find that when anhydrous benzoylation (2–3½ hr.) is applied to tissue specimens and is followed by the Sakaguchi procedure[1], the colour reaction of arginine groups is completely prevented in the cell cytoplasm, while a definite nuclear reaction persists. This holds true (with one exception noted later) for all material so far examined, namely, sections or smears from many tissues (and sperm) from rat and mouse, as well as locust testis and root tips of *Vicia* and *Trillium*. Frozen-dried, frozen-substituted and Lewitsky-fixed specimens all give this characteristic effect after benzoylation. Measurements on rat liver made thus will be reported elsewhere[5]. *p*-Nitrobenzoyl chloride[4] produces a similar result.

A complication in the interpretation of the results of the normal Sakaguchi method itself is shown by our further observation that frozen-dried or frozen-substituted tissues, fixed in sections or smears by absolute ethanol and treated by the Sakaguchi method alone, show in general no nuclear reaction, either by eye or two-wave-length spectrophotometry, except in the sperm head. A normal reaction is seen in the cytoplasm. This is in contrast to the relatively strong nuclear reaction found after various chemical fixatives, for example, in Lewitsky's fluid, and raises the question of diffusion artefacts in the fixation and reaction. This has been examined by interference microscope measurements of the changes in dry mass of cell nuclei exposed to the Sakaguchi reaction mixture, after various initial treatments. The results (Table 1) show that the negative nuclear reaction in frozen-dried or frozen-substituted specimens is due to a very considerable removal of nuclear material in the strongly alkaline medium. This is largely extracted into the medium, although some may be adsorbed and contribute to the observed cytoplasmic reaction for arginine. Coating the specimen with 'Celloidin' does not prevent this loss. The extraction can be prevented either by benzoylation or, in part, by treatment with Lewitsky's fluid (Table 1). In the latter case there is an apparent greater retention after 'Celloidin' coating[6], although re-distribution of dissolved material under the 'Celloidin' film must then be a possible source of error. Results very similar to those in Table 1 have also been obtained on frozen-dried tissue sections (with and without benzoylation).

Table 1. Changes in Dry Mass of Individual Cell Nuclei after Exposure to Sakaguchi Reaction Medium

Treatment*	Material†	No. of samples	No. of nuclei	Dry mass‡ of nucleus after exposure§ (per cent)
None	Mouse kidney	2	‖	<10
	Mouse liver	2	‖	<10
	Rat liver	2	‖	<10
	Mouse sperm heads	1	6	100
Benzoylated (2½–3 hr.)	Mouse kidney	1	6	95
	Mouse liver	3	12	99
	Rat liver	1	5	103
	Mouse sperm heads	1	3	105
Lewitsky (ref. 1)	Mouse kidney	3	10	63
	Mouse liver	1	3	40¶
	Mouse sperm heads	1	3	100
Lewitsky ('Celloidin' coated) (ref. 1)	Mouse kidney	1	6	76
	Rat liver	1	8	91

* All smears were initially frozen-substituted in methanol (minimum 24 hr.), then fixed in ethanol for ½–1 hr. (Extension of fixation to 24 hr. does not change the behaviour.)

† Smears containing whole cells and whole nuclei. Homogeneous nuclei of regular geometry were selected for measurement.

‡ Measured using Baker interference microscope, with half-shade eye-piece and × 100 shearing objective. Corrected for any change in measured area of nucleus. The same nucleus was measured in each case, in water, before and after treatment, and the final value expressed as percentage of the initial value. No significance is attached to changes of less than 10 per cent. (Means for all nuclei are recorded.)

§ Medium is 0·6 per cent sodium hydroxide (30 ml.) + 1·2 per cent sodium hypochlorite (1·2 ml.) + 70 per cent ethanol (1 ml.). Exposed 7 min., then washed with water.

‖ Exact measurements could not be performed here after exposure; all nuclei in the field were swollen and of extremely low dry mass. 'Celloidin'-coated samples gave the same results.

¶ Approximate only, due to considerable swelling.

These observations lead us to conclude:

(1) Benzoyl chloride, in the anhydrous medium, reacts at the guanidino groups of arginine (cf. ref. 7 for a similar benzoylation of arginine side-chains in isolated proteins). This reaction proceeds in the proteins in the cell cytoplasm, and probably in some nuclear proteins; but a certain fraction of nuclear protein arginine is unable to react with this reagent. This fraction alone is revealed by the subsequent Sakaguchi reaction which cannot proceed at acylated guanidino groups. The most probable reason for the non-availability of this nuclear arginine fraction is that these are the arginine side-chains considered to be bound in salt linkage[8] to deoxyribonucleic acid phosphate groups. It is presumed that these arginine side-chains, in contrast to those in other situations, are held in the charged form even in the anhydrous pyridine–acetonitrile medium and so cannot be acylated. However, all types of arginine side-chains are reactive in the Sakaguchi method due to discharge in the aqueous alkali which must (for this same reason) be employed.

Further evidence for the above interpretation is that, while the reaction is in general confined to the cell nucleus and, in fact, virtually to the chromosomes in dividing cells, a cytoplasmic reaction is also found in one case, namely, where a high accumulation of ribonucleoprotein is present, that is, in the basal strongly basophilic region of active pancreatic acinar cells (in contrast to the negative cytoplasm of neighbouring cells of other types), and also in certain plant root meristem cells. Presumably salt-linked arginine groups are present there, too. The blocking reaction is not sensitive to prior water treatment, as it is in the case of histidine groups[2,4], again consistent with a stable salt linkage. Prolonged benzoylation (18 hr.) does not abolish the reaction, that is, a merely kinetic difference is not involved.

(2) While it is preferable to employ freeze-drying or freeze-substitution, to avoid initial diffusion errors, these processes (followed by ethanol fixation) leave the nucleoprotein soluble in the alkaline medium, and this must be countered by treatment of the type described. Benzoyl chloride is presumably effective in this instance due to the insolubilizing effect of benzoyl groups introduced at other sites in the nucleoprotein (an effect we have confirmed on isolated calf thymus histone). Even after such treatment, the possibility of diffusion errors, below the limits of total mass measurements by interferometry of the present type, remains in the Sakaguchi method.

(3) The method described can be applied to tissue specimens without isolation of nuclei, for the microspectrophotometric measurement of the nuclear arginine fraction in question. Measurements to support and extend these observations will be reported elsewhere[5].

The plant material used was kindly supplied by Dr. J. Chayen and Mr. L. F. LaCour.

E. A. Barnard
L. G. E. Bell

Department of Zoology,
University of London, King's College,
Strand, London, W.C.2.

[1] McLeish, J., Bell, L. G. E., LaCour, L. F., and Chayen, J., *Exp. Cell Res.*, **12**, 120 (1957).
[2] Barnard, E. A., and Danielli, J. F., *Nature*, **178**, 1450 (1956).
[3] Bell, L. G. E., in "Physical Techniques in Biological Research", **3**, edit. by Oster, G., and Pollister, A. W. (Academic Press, New York, 1956).
[4] Barnard, E. A., in "General Cytochemical Methods", **2**, edit. by Danielli, J. F. (Academic Press, New York, 1960; in the press).
[5] Barnard, E. A., and Looney, W. B. (in preparation).
[6] Baker, J. R., *Quart. J. Micro. Sci.*, **85**, 1 (1944).
[7] Olcott, H. S., and Fraenkel-Conrat, H., *Indust. Eng. Chem.*, **38**, 104 (1946).
[8] Wilkins, M. H. F., *Biochem. Soc. Symp.*, **14**, 13 (1957).

Reversible Dissociation of Ribonucleic Acid

The work reported here was prompted by the observation that when infectious ribonucleic acid, isolated from Ehrlich ascites cells infected with Mengo encephalomyelitis virus[1], was incubated with crystalline bovine plasma albumin in solutions of physiological ionic strength, its biological activity was lost or sharply inhibited. No loss of infectivity was observed when mixtures of these two substances were incubated in concentrated solutions of sodium chloride (0·6–1·0 *M*). However, infectivity was not regained when protein–ribonucleic acid mixtures in physiological saline were made 0·64 *M* with respect to sodium chloride. The biological activity of the Mengo ribonucleic acid and of the Mengo ribonucleic acid–bovine plasma albumin mixtures was assayed by a plaque method employing monolayers of Earle's *L* strain mouse fibroblasts[2].

The ribonucleic acid used in the experiments described here was isolated from Ehrlich ascites tumour cells by the phenol method previously described[3]. The fraction of high molecular weight was separated from material of low molecular weight by precipitation in 1 *M* sodium chloride. In the analytical ultracentrifuge this fraction showed two peaks with sedimentation velocities of 16–18 S. and 32–34 S., respectively, the component sedimenting

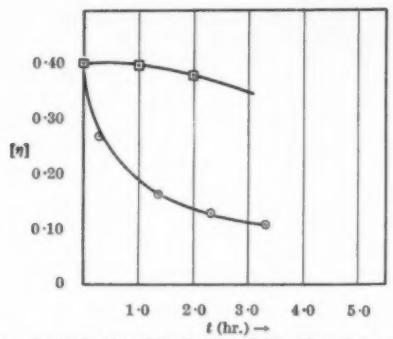


Fig. 1. Intrinsic viscosity of ribonucleic acid (1·2 mgm./ml.), —⊡—; and of a ribonucleic acid (1·2 mgm./ml.)–α-lactalbumin (5 mgm./ml.) mixture, —○— in physiological saline

more rapidly comprising 60–65 per cent of the total. All ultracentrifugal analyses were performed in the 'Spinco' model *E* ultracentrifuge, using either schlieren optics or ultra-violet absorption and the 'Analytrol' with the microanalyser attachment[4].

The interaction of ribonucleic acid with three different proteins, namely, bovine plasma albumin, bovine γ-globulin, and α-lactalbumin (kindly supplied by D. Martin Kronman, Eastern Regional Laboratories, United States Department of Agriculture) has been studied. Under the proper conditions, the admixture of protein and ribonucleic acid in solutions of physiological ionic strength results in the conversion of the 16 S. and 32 S. components or ribonucleic acid into components sedimenting more slowly. Since these changes in sedimentation properties are accompanied by a decrease in the viscosity and turbidity of the solutions, it seems reasonable to assume that they reflect a dissociation of the ribonucleic acid. The degree of dissociation depends on the protein used, the ratio of protein to ribonucleic acid concentration, and the absolute concentrations of each. The dissociation can be partially or completely reversed by making the solution 1 *M* with respect to sodium chloride or 0·01 *M* in magnesium sulphate. Neither the conversion of ribonucleic acid into slowly sedimenting components in physiological saline solution nor the regeneration of the rapidly sedimenting components occurs rapidly. At 4° C., 2–4 hr. are required for the first process, and a somewhat longer period is required for the second.

At concentrations of ribonucleic acid greater than 1 mgm./ml., bovine plasma albumin did not affect the sedimentation velocity of the nucleic acid. However, in a solution containing 20 and 400 μgm./ml. of ribonucleic acid and bovine plasma albumin, respectively, most of the nucleic acid was found to sediment with the bovine plasma albumin peak. The sedimentation constant of the latter increased from 4·3 to 5·1–5·3 S. The rapidly sedimenting components of ribonucleic acid were regained when the solution was made 1 *M* with respect to sodium chloride, or 0·01 *M* with respect to magnesium sulphate.

α-Lactalbumin is a protein with a molecular weight of 15–17,000 and a sedimentation constant of 1·6 S. Because of its small size, it is particularly well suited for studies of ribonucleic acid–protein interaction. Fig. 1 shows the changes in the intrinsic viscosity of a ribonucleic acid solution (1·2 mgm./ml.) when incubated with α-lactalbumin (5 mgm./ml.). Although incubation of the ribonucleic acid alone produced a decrease in the viscosity of the solution, it was slight compared with the very rapid decrease which resulted from addition of protein. In a similar mixture, incubated for 12 hr. at 4° C., a new peak with a sedimentation constant of 3·0 S. appeared. The addition of sodium chloride only partially reversed the dissociation.

It was possible to dissociate ribonucleic acid by means of bovine γ-globulin at all concentrations of ribonucleic acid and protein. The degree of dissociation depended on the ratio of protein to ribonucleic acid. At high ratios there was complete dissociation, and all the ribonucleic acid travelled with the protein peak in the ultracentrifuge. At lower ratios there was less dissociation. It was possible to reverse the dissociation in mixtures containing low concentrations of ribonucleic acid and a low ratio of protein to ribonucleic acid, while only partial reversal was obtained under other conditions.

In Fig. 2, the distribution of sedimentation constants observed by means of ultra-violet optics in a mixture containing 50 μgm./ml. bovine γ-globulin and 25 μgm./ml. ribonucleic acid is presented. The distribution shown in Fig. 2*A* was obtained after the mixture had stood for 2 hr. in 0·14 *M* sodium chloride, buffered at *p*H 7·0 with phosphate of ionic strength 0·01. At that time, an aliquot was made 0·01 *M* with respect to magnesium sulphate. The distribution in Fig. 2*B* was obtained with the latter aliquot 3 hr. after the addition of magnesium salt. Since the protein contributed only about 5 per cent of the optical density, the distributions are essentially those of the ribonucleic acid.

Our results suggest that ribonucleic acid exists in dynamic equilibrium with sub-units, and that the equilibrium is shifted towards dissociation by binding of the sub-units by protein. If this is true, it should be possible to demonstrate such an equilibrium without the use of protein. A partial separation of the 16–18 S. component in the ultracentrifuge by means of a partition cell[4] did give fractions the sedimentation properties of which changed with time so as to approach those of the original solution. The fractions were unstable and regenerated the high molecular weight (32 S.) peak only if fractionation had been inefficient.

One may sum up these findings by saying that the dissociation of ribonucleic acid is a reversible process if it is not carried too far. If it is assumed that the irreversible dissociation does not involve degradation,

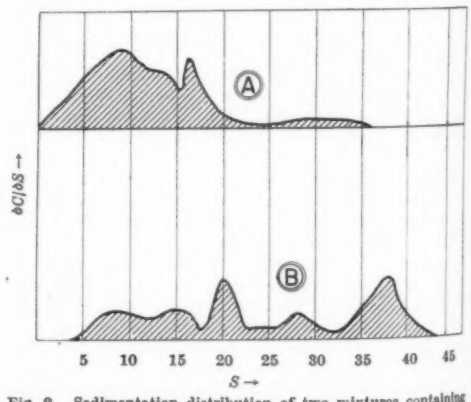


Fig. 2. Sedimentation distribution of two mixtures containing 50 μgm./ml. bovine γ-globulin and 25 μgm./ml. ribonucleic acid: (*A*) 3 hr. after mixing in physiological saline; (*B*) 6 hr. after mixing and 3 hr. after making the mixture 0·01 *M* with respect to magnesium ions

but rather a failure to re-assemble the molecule in a specific order by random processes, the measured sedimentation constant of 3·0 S. and intrinsic viscosity of 0·1 (Fig. 1) obtained with a mixture of ribonucleic acid and α-lactalbumin may be used to estimate the probable sub-unit size at 35–75 nucleotides. Considering only the reversible dissociation seen with bovine γ-globulin and bovine plasma albumin, the sedimentation results (Fig. 2) can be employed to estimate an upper limit of 200 nucleotides for the sub-unit size.

The results of Loring *et al.*[5] would suggest that the ribonucleic acid of tobacco mosaic virus is capable of reversible dissociation into sub-units, with retention of potential biological activity. The recovery of infectivity implies a specific re-assemblage of the ribonucleic acid molecules.

This work has been supported by grants from the National Institutes of Health (*C*-4534 and 2*G*-142-*C*1), the American Cancer Society (*E*-89), and the Samuel S. Fels Fund.

R. A. Brown
K. A. O. Ellem*
J. S. Colter

Wistar Institute of Anatomy and Biology,
36th Street at Spruce,
Philadelphia 4.

* Travelling Fellow of the N.S.W. State Cancer Council.

[1] Colter, J. S., Bird, H. H., and Brown, R. A., *Nature*, **179**, 859 (1957).
[2] Ellem, K. A. O., and Colter, J. S., *Virology* (in the press).
[3] Colter, J. S., and Brown, R. A., *Science*, **124**, 1077 (1956).
[4] Schachman, H. K., "The Ultracentrifuge in Biochemistry" (Academic Press, New York, 1959).
[5] Loring, H. S., Fujimoto, Y., and Eng, L. F., *Proc. U.S. Nat. Acad. Sci.*, **45**, 287 (1959).

Carbohydrates of *Ecklonia radiata*

In connexion with our work on the chemistry of cellulose and related carbohydrates, it was found desirable to investigate certain properties of algal polysaccharides. In seeking a source of these materials we noted that Australian species of brown algæ appear to have received little chemical study, although the carbohydrates of *Ecklonia maxima*, *Laminaria pallida* and *Bifurcaria brassicaeformis* of South Africa have been investigated[1]. The northern hemisphere species, especially of the genus *Laminaria*, have been studied in considerable detail[2,3]: large seasonal variations occur in the contents of laminarin (0–30 per cent), alginic acid (10–30 per cent) and mannitol (0–30 per cent); the fucoidin content is low and less variable[3,4].

Recently we have made a preliminary study of the carbohydrate components of *Ecklonia radiata* (Ag.) J. Ag., which occurs in the sub-littoral zone of the southern coasts of Australia. Fresh whole seaweed, collected in autumn at Point Lonsdale, Victoria, was milled through breaker plates in a Bauer defibrator and the carbohydrates were extracted from the milled material with 1 per cent hydrochloric acid by a two-stage steeping treatment, essentially as described by Black *et al.*[5]. On allowing the solution to stand for several days, little or no insoluble laminarin was precipitated. One fraction (I) of polysaccharides was precipitated by the addition of ethanol to a concentration of 74 per cent, another (II) by further addition of ethanol to the supernatant to a final concentration of 85 per cent. The polysaccharides (I + II) were obtained in a yield of about 6 per cent by redissolving the precipitates in a small amount of water and triturating with ethanol and ether. Fraction I consisted of laminarin and fucoidin; fraction II almost entirely of laminarin. Fractional precipitation of I with ethanol gave only a partial separation of the soluble laminarin and fucoidin. However, part of the fucoidin could be removed on an anion-exchange resin (a similar method has been used by Unrau, A., and Smith, F.; personal communication), 'Duolite *A*4', after first passing the solution through 'Amberlite *IR*-120(H)' to remove calcium and other cations. A more satisfactory separation was achieved by treatment with cetyl trimethylammonium bromide. The polysaccharides were identified by infra-red spectroscopy and the components of their acid hydrolysates by chromatography, in some cases combined with infra-red examination of sugars eluted from chromatograms and freeze-dried.

Further work was done with samples collected in summer. Mannitol was extracted with butanol[1], and crystallized from butanol and from ethanol; it was characterized by chromatography, physical constants and infra-red spectroscopy. Alginic acid was obtained by alkaline extraction of plant material from which other carbohydrates had been removed. It was isolated as the free acid and sodium salt, which were compared with authentic samples. Analyses were carried out according to the methods developed by Cameron, Ross and Percival[6]. The average contents for December–January were found to be as follows:

	Laminæ	Midrib*
Mannitol (per cent)	16	13
Alginic acid (per cent)	20	26
Laminarin (per cent)	5·4	1·8
Fucoidin (per cent)	1·0	1·2

* The 'midrib' is that portion of the frond, comprising the elongation of the stipe, from which the 'laminæ' have been removed.

The seasonal variation in the content of the four carbohydrates is of interest in connexion with their biochemical function and possible utilization. This aspect of the work and others are receiving attention, and will be reported elsewhere. We wish to thank Miss S. Austin, Mr. K. J. Harrington and Mr. G. Davies for help with this work.

C. M. Stewart
H. G. Higgins

Division of Forest Products,
Commonwealth Scientific and Industrial
Research Organization, South Melbourne.

[1] Von Holdt, M. M., Ligthelm, S. P., and Nunn, J. R., *J. Sci. Food Agric.*, **6**, 193 (1955).
[2] Black, W. A. P., *J. Mar. Biol. Assoc. U.K.*, **29**, 45, 379 (1950).
[3] Mori, T., "Advances in Carbohydrate Chemistry", **8**, 315 (1953). (Review).
[4] Black, W. A. P., *J. Soc. Chem. Industr.*, **67**, 165 (1948).
[5] Black, W. A. P., Cornhill, W. J., Dewar, E. T., and Woodward, F. N., *J. App. Chem.*, **1**, 505 (1951).
[6] Cameron, M. C., Ross, A. G., and Percival, E. G. V., *J. Soc. Chem. Industr.*, **67**, 161 (1948).

Fatty Acid Composition of the Lipids of Pasture Grasses

Little information is available on the total fatty acid composition of pasture grass lipids. Shorland[1,2] reported that the fatty acids of the acetone-soluble lipids of cocksfoot grass and of rye grass grown in New Zealand comprised about 3 per cent of the dry matter of the grass; ester-fractionation analysis showed that saturated acids (mostly palmitic) accounted for less than 20 per cent of the total acids and that the remaining unsaturated acids consisted largely of linoleic and linolenic acids. Details were

not given of the analysis of the fatty acids of the acetone-insoluble lipids (phospholipids), though it was stated[1] that those from cocksfoot grass resembled the fatty acids of the corresponding acetone-soluble lipids, except for a somewhat lower mean unsaturation of the C_{18} unsaturated components. In earlier work Smith and Chibnall[2] isolated the phospholipid fatty acids of cocksfoot grass and showed that they consisted mainly of linoleic, linolenic and saturated components. Contrary to the assumption hitherto made that the acetone-soluble lipids of forage grasses are mainly triglycerides, plus unsaponifiable matter, Weenink[4] has recently shown that about 60 per cent of this lipid fraction of New Zealand grasses consists of galactosyl glyceryl esters of fatty acids, largely linolenic acid.

As part of investigations on the fate of dietary lipids in the rumen of the sheep a detailed analysis was made of the total fatty acids of artificially dried milled grass containing about 50 per cent of perennial ryegrass, 25 per cent of cocksfoot, 15 per cent of timothy grass and 10 per cent of Italian ryegrass grown in Aberdeenshire and cut in July 1959. The material was exhaustively extracted successively with hot 95 per cent ethanol and hot chloroform–methanol (2 : 1 by vol.). The lipids in each extract were hydrolysed with ethanolic potassium hydroxide, unsaponifiable matter was removed and the fatty acids were recovered. The fatty acids obtained from the ethanolic extract and from the chloroform–methanol extract, respectively, represented 2·02 and 0·27 per cent of the dried grass and hence 88·2 and 11·8 per cent of the total fatty acids.

Each group of fatty acids was converted to methyl esters for analysis by gas chromatography, employing polymerized ethylene glycol succinate (prepared as for the adipate[5]) as liquid phase at 170° C. and argon as carrier gas. In Table 1 is shown the composition of each group of acids and the resultant composition of the total fatty acids of the grass lipids.

Table 1. Fatty Acid Composition of Pasture Grass Lipids
(Values as percentage by weight of total acids in each group)

Acid	Source of fatty acids		Total fatty acids
	Lipids extracted with ethanol	Lipids extracted with chloroform–methanol	
Myristic	1·2	0·8	1·1
Palmitic	14·4	26·8	15·9
Palmitoleic	2·5	2·6	2·5
Stearic	1·7	4·4	2·0
Oleic	3·2	5·1	3·4
Linoleic	12·8	15·4	13·2
Linolenic	64·2	39·6	61·3
Arachidic	—	2·1	0·2
Behenic	—	3·2	0·3

The two groups of fatty acids contributing to the total acids are broadly similar in composition, though the lipids of the chloroform–methanol extract contain relatively more palmitic acid and less linolenic acid than the lipids of the ethanol extract and, in addition, are characterized by the presence of small amounts of arachidic and behenic acids. The total fatty acid composition resembles closely that of the leaf lipids of maize[6] (another graminaceous plant) and also that of the lipids of clover-rich pasture[7]. Linolenic acid is the outstanding component, and the unsaturated C_{18} acids together make up more than 75 per cent of the total acids; of the saturated fatty acids present, palmitic acid predominates.

The lipids in each of the two extracts of the dried grass were subjected to a preliminary fractionation. The ethanol-soluble lipids were subjected to chromatography on silicic acid (cf. Garton and Duncan[8]); a fraction eluted with 5 per cent ether in light petroleum contained free fatty acids and neutral lipid. The free acids were isolated and found to comprise 13·5 per cent of the total fatty acids of the grass; their composition is shown in Table 2. Following saponification and removal of unsaponifiable matter, fatty acids accounted for 92 per cent of the remaining neutral lipid, which was thus taken to be triglyceride. These fatty acids represented only 3·3 per cent of the total fatty acids of the grass. Subsequent elution with 10 per cent methanol in ether removed lipid corresponding to 62 per cent of the ethanol-soluble lipids. This fraction apparently consists of galactosyl glyceryl esters as described by Weenink[4]; hydrolysis gave glycerol, galactose and fatty acids, of which linolenic acid accounted for 82·0 per cent (Table 2).

Table 2. Fatty Acid Composition of Fractions derived from the Ethanol-Soluble Lipids
(Values as percentage by weight of total acids in each group)

Acid	Source of fatty acids		
	Free fatty acids	Triglycerides	Fraction eluted with 10 per cent methanol in ether
Myristic	1·6	3·3	0·2
Palmitic	13·0	14·6	7·0
Palmitoleic	2·4	1·8	1·6
Stearic	1·6	2·9	1·5
Oleic	4·3	8·1	1·8
Linoleic	17·4	23·1	5·9
Linolenic	59·7	46·2	82·0

The lipids extracted with chloroform–methanol were separated into acetone-soluble and acetone-insoluble (phospholipid) portions. Of the total fatty acids in the lipids in the chloroform–methanol extract, 30 per cent (including almost all the arachidic acid and behenic acid) were present in the acetone-insoluble portion; the acetone-soluble lipids were relatively richer in linolenic acid than the acetone-insoluble lipids.

Further work on the nature of the lipids of grasses and other animal feeds is in progress.

G. A. Garton

Rowett Research Institute,
Bucksburn, Aberdeen.

[1] Shorland, F. B., *Nature*, **153**, 168 (1944).
[2] Shorland, F. B., *J. Sci. Food Agric.*, **4**, 497 (1953).
[3] Smith, J. A. B., and Chibnall, A. C., *Biochem. J.*, **26**, 1345 (1932).
[4] Weenink, R. O., *N.Z. J. Sci.*, **2**, 273 (1959).
[5] James, A. T., personal communication; cf. Farquhar, J. W. Insull, W., Rosen, P., Stoffel, W., and Ahrens, E. H., in Supplement to *Nutrit. Rev.*, **17** (August 1959).
[6] Crombie, W. M., *J. Exp. Bot.*, **9**, 254 (1958).
[7] Shorland, F. B., Weenink, R. O., and Johns, A. T., *Nature*, **175**, 1129 (1955).
[8] Garton, G. A., and Duncan, W. R. H., *Biochem. J.*, **67**, 340 (1957).

PHYSIOLOGY

A Biological Interval Analyser

A frequent requirement in the analysis of biological data is the classification of time-intervals. Thus one might wish to know the most probable interval between heart-beats, or the most probable reaction time of forefinger movements in response to sound. The usual way of acquiring this sort of information is by manual measurements of relatively long biological records. This method, however, can

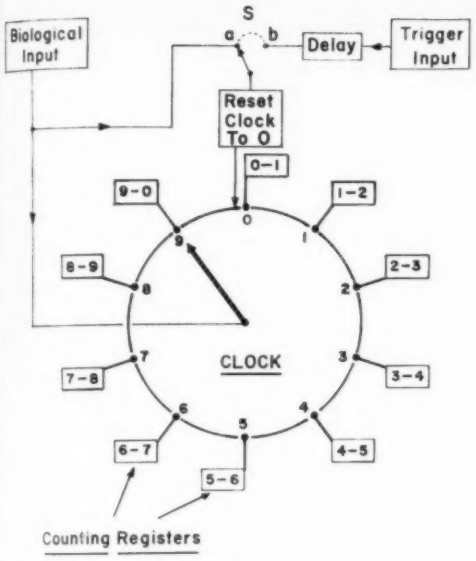


Fig. 1

become extremely time-consuming when the number of biological signals to be classified is large. An example may serve to illustrate our point. The neurons of the unanæsthetized, unstimulated cat's brain are in a state of continual 'spontaneous' activity. Their mean frequency of discharge per minute is constant (some 5–20/sec.) when observed over long periods of time, but it appears impossible to predict with certainty the exact time at which the next action potential in a series will occur. Cells in the resting visual cortex are also engaged in continual activity, but will respond to a flash of light focused upon the retina with an increased probability of discharge. One can state the relationship between stimulus and response in these circumstances only in terms of probability, since any particular flash of an identical series may or may not be followed by an action potential.

There are, thus, two questions one might reasonably ask about the behaviour of cells in the unanæsthetized cerebral cortex. (1) Is the resting discharge of the neurons random with respect to time? (2) What is the probability that an action potential will occur within a specified interval of time after the stimulation? The manual analysis of two minutes of record from cortical units may involve the measurement and classification of some 1,200 intervals and can occupy one full man-day. For this reason we have designed and built an electronic interval analyser which provides an instantaneous display of the completed analysis.

A functional diagram of this device is shown in the accompanying figure. The central component is a clock which connects the biological input in succession to each of ten digital counting registers. Suppose that we require to know the distribution of intervals between discharges of a single neuron in the 'resting' brain. The rate of revolution of the clock is first pre-set to a convenient value so that the biological signals are fed to each of the counting registers for, say, 100 m.sec. The switch S is set to position a. The first action potential causes the clock to jump from its resting position 9 to position 0, where in the absence of another action potential it rests for 100 m.sec. and then jumps to position 1. If the next action potential arrives during the next 100 m.sec., the event is recorded in counting register 1–2 and the clock is reset simultaneously to position 0. In this way, the intervals between successive action potentials are measured and classified. All intervals between action potentials that are greater than 9×100 m.sec. will be accumulated in register 9–0. At the end of a series of action potentials the counting registers of the instrument display numbers proportional to the probabilities of occurrence of various intervals between action potentials.

Another mode of operation of the analyser provides the probabilities that action potentials will occur at various times after the stimulation. For this operation the switch S is turned to b, when initiation of the clock-cycle is triggered by a pulse synchronous with stimulation. Suppose that the clock's rotation is pre-set so that it spends 20 m.sec. in each position. Suppose also that the frequency of repetition of a stimulus is 1 per sec. The first stimulus of a series will move the clock from position 9 to position 0 and initiate its stepwise progress. Should an action potential occur during the 20 m.sec. that the clock rests on position 2, then the event will be stored in register 2–3. The clock is not reset by this action potential, but continues to move consecutively through positions 3–9, distributing action potentials to the appropriate registers. Once the clock attains position 9 it waits there until the next stimulus begins the cycle again. At the end of the analysis, counts appear in the registers which are proportional to the probabilities of response 0–20, 20–40 . . . 160–180, 180–1,000 m.sec. after the stimulus. By use of the variable delay indicated in the figure, it is equally easy to obtain probabilities of response 180–200, 200–220, . . . m.sec. after the stimulation.

Although this instrument was specifically designed for the analysis of the behaviour of central neurons, its use is clearly not limited to this function. The same instrument could, for example, be employed with equal ease to make similar analyses of cardiac rhythm, respiratory activity, or animal behaviour in conditioning experiments.

G. K. Smith
B. Delisle Burns

Department of Physiology,
McGill University,
Montreal.

Depressing Activity of Meprobamate on the Reticulo-Endothelial System

Data in the literature point to tranquillizers as drugs having a certain influence on the responsiveness to infections. Patients treated with reserpine or chlorpromazine have decreased resistance to infectious diseases[1,2].

Chlorpromazine increases susceptibility of mice to infection with *Salmonella enteritidis*[3] and depresses the phagocytic activity of the reticulo-endothelial system[4]. The production of anti-*Salmonella typhimurium* agglutinins in rabbits is decreased by meprobamate[5]. Vinegar and Berger[6] found that the clearance-rate of carbon particles in blood of mice is depressed 24 hr. after the administration of a single high dose of certain tranquillizers. Meprobamate at two dose-levels (100 and 200 mgm./kgm.) does not

affect clearing. They attributed the depression of the reticulo-endothelial system as due to the liberation of corticosteroids from the adrenal cortex caused by the tranquillizers. It is known in fact that corticosteroids inhibit the clearing of carbon particles by the reticulo-endothelial system[7,8] and that chlorpromazine induces adrenocorticotrophic hormone release from the hypophysis[9] and hypertrophy of the adrenal cortex[10]. On the other hand, adrenalectomy has been reported as a condition which does not affect clearing[6,11] and that the depression of the reticulo-endothelial system does not appear in adrenalectomized hydoxyzine-treated mice[6]. It seemed, therefore, of some interest to investigate the influence of meprobamate, given in therapeutical doses and for more than one single administration, on the reticulo-endothelial system and to have more evidence for supporting the theory of the interference of the adrenal cortex.

Table 1. Carbon Clearance in Normal, Meprobamate-treated and Adrenalectomized Mice
(Means ± standard errors)

Group	Days of treatment	K ($\times 10^{-2}$)	$T/2$	α
Controls (9)	—	12·8 ± 0·74	24′ ± 1·23	4·22 ± 0·23
Meprobamate-treated (6)	3	6·9 ± 0·43*	44′ ± 2·68*	2·79 ± 0·32†
Meprobamate-treated (6)	7	12·7 ± 0·96§	21′ ± 0·91§	3·83 ± 0·15§
Meprobamate-treated (6)	15	7·7 ± 0·96*	42′ ± 6·16†	3·42 ± 0·13‡
Adrenalectomized (14)	—	7·2 ± 0·57*	55′ ± 6·18*	2·72 ± 0·18*

Number of animals in parentheses. * $P < 0.001$; † $0.001 < P < 0.005$; ‡ $0.01 < P < 0.02$.; § N.S.

Male Rockland-Swiss mice weighing 20 gm. were divided into three groups; one served as control and received saline, another was given subcutaneously 25 mgm./kgm. of meprobamate and another was adrenalectomized. Clearance of carbon particles was carried out as described by Heller *et al.*[12], and determined in the meprobamate-treated group after 3, 7 and 15 days of treatment, and in the adrenalectomized group after 7 days in the surviving animals. For each animal was then calculated: the phagocytic index (K), that is, the constant of the equation of disappearance of carbon from blood, the half-time of carbon disappearance ($T/2$) and the corrected phagocytic index (α), which measures the phagocytic activity per unit weight of liver and spleen. The results are summarized in Table 1. From the results it appears that the activity of the reticulo-endothelial system is strongly depressed at the beginning of the treatment with meprobamate, returns almost to normal after 7 days and is again depressed after 15 days. Our results for the effects of adrenalectomy do not agree with those of other authors and do not allow the possibility of investigating the effects of meprobamate on the adrenalectomized animals. So far as the mechanism by which meprobamate affects the reticulo-endothelial system is concerned, it may be supposed that the tranquillizer induces at the beginning a 'block' of the adrenal cortex function (depression of clearing) which returns to normal in a few days (almost normal clearing); the continuous administration of the tranquillizer leads later on to an increased secretion of adrenal corticoids which may explain the depressed activity of the reticulo-endothelial system after 15 days of treatment.

A. Del Vecchio
L. Bolis

Lab. Studi e Ricerche,
Istituto Ganassini,
Milan.

[1] Kline, N. S., *et al.*, *Dis. Nerv. Syst.*, **17**, 352 (1958).
[2] Wardell, D. W., *Amer. J. Psychiat.*, **185**, 235 (1956).
[3] Grosz, H. J., and Norton, J., *Science*, **129**, 784 (1959).
[4] Meier, R. M., *et al.*, *Fed. Proc.*, **16**, 425 (1957).
[5] Compagnucci, M., *et al.*, *Boll. Soc. Ital. Biol. Sper.*, **35**, 313 (1959).
[6] Vinegar, R., and Berger, F. M., *Proc. Soc. Exp. Biol. Med.*, **102**, 88 (1959).
[7] Heller, J. H., in "Physiopathology of Reticulo-endothelial System" edit. by Halpern, 45 (Blackwell, Oxford, 1957).
[8] Bilbey, D. L., and Nicol, T., *Nature*, **182**, 674 (1958).
[9] Egdahl, R. H., and Richards, J. P., *Amer. J. Physiol.*, **185**, 235 (1956).
[10] Hormia, M., *Ann. Med. Exp. Fenn.*, **36**, Supp. 3 (1958).
[11] Benacerraf, B., *et al.*, in "Physiopathology of Reticulo-endothelial System", edit. by Halpern, 67 (Blackwell, Oxford, 1957).
[12] Heller, J. H., *et al.*, *J. Endocrinol.*, **61**, 235 (1957).

Anti-Fertility Action of a Monoamine Oxidase Inhibitor

An earlier communication has directed attention to the anti-inflammatory properties of inhibitors of monoamine oxidase[1]. Similar properties for iproniazid, one such substance, have been described independently[2]. The similarities between the vascular events of implantation of the fertilized ovum and of the inflammatory reaction, together with the low toxicity of certain monoamine oxidase inhibitors, prompted the trial of these compounds as orally administered inhibitors of conception. The work was also stimulated by reports of the effect of 5-hydroxytryptamine and iproniazid in terminating pregnancy in mice[3].

Female albino rats of the Wistar strain, weighing 150–250 gm., were caged with similar male rats (one male to every five or six females) for a mating period of 9 days, the males then being removed. Animals receiving the monoamine oxidase inhibitor did so in their drinking water. The drug used was (1-methyl-2-phenoxyethyl)hydrazinium (compound *HP*1275) obtained from Smith and Nephew Research, Ltd. The dosage ranged from 0·1 to 0·5 mgm. per ml. of drinking water. The nature of the experiment meant that both female and male rats received the drug throughout the period of mating. The females were, however, put on the drug 24 hr. before the males were added to their cage.

Table 1 shows that the higher dose led to complete suppression of fertility. Both female and male rats on this regime showed no obvious abnormality or disturbance of health. The lower dose-levels showed less striking effects.

Table 1. Effect of Compound *HP*1275 on the Incidence of Pregnancy in Rats and Mice

Concentration of *HP*1275 in drinking water (mgm./ml.)	Animal	Approximate dose (mgm./kgm./24 hr.)	No. of females	No. of females pregnant	Pregnant (per cent)
None	Rat	None	48	24	50
0·5	Rat	25	48	0	0
0·25	Rat	12	20	4	20
0·10	Rat	5	20	8	40
None	Mouse	None	48	9	19
0·5	Mouse	25	48	3	6

A similar experiment was conducted with mice, using a four-day mating period in which both males and females received 0·5 mgm./ml. of compound *HP*1275 in their drinking water. The results here were less impressive although the incidence of pregnancy was reduced. Female rats which had received 0·5 mgm./ml. of *HP*1275, when mated three weeks later without the addition of the drug to their drinking water, conceived normally. Of 24 females so treated, 11 became pregant and delivered normal litters which survived.

Although the effect in rats was striking, interpretation is difficult. It is not certain whether the action of the drug is on the female or partly or wholly on the male. It has not yet been possible to devise an experiment in which animals of only one sex received the drug and yet in which there was an adequate mating period with minimal handling of the animals. However, other results indicate that the action is probably on the female[2].

Compound *HP*1275 has been administered to male and female rats for several months in doses up to 50 mgm./kgm./24 hr. without detectable clinical or histologicl aabnormalities. A general toxic basis for the anti-fertility effect of the drug is therefore rather less likely than a more specific action. However, it cannot be said to be established that the drug acts by inhibition of monoamine oxidase.

Two suggestions may be made. The compound may prevent the destruction of a vasoconstrictor amine at the site of implantation, thus preventing vascular changes essential for this process to be completed[1]. Alternatively, it may stimulate hormonal secretion in the pituitary-suprarenal axis of a nature unfavourable to the establishment of pregnancy. Such stimulation could be direct or indirect through the mediation of pressor amines.

W. G. Spector

Department of Morbid Anatomy,
University College Hospital Medical School,
London, W.C.1.

[1] Spector, W. G., and Willoughby, D. A., *Nature*, **186**, 162 (1960).
[2] Setnikar, I., Salvaterra, M., and Temelcou, O., *Brit. J. Pharm.*, **14**, 484 (1959).
[3] Poulson, E., Botros, M., and Robson, J. M., *Science*, **131**, 1101 (1960).

Reversibility of an Inherited Metabolic Block (Inborn Error of Metabolism)

The irreversibility and permanence of the basic defects in 'inborn errors of metabolism' have been regarded hitherto as essential pre-requisites of the condition as defined by Garrod[1]. The question is whether in the light of the following observations this aspect of Garrod's concept can yet be universally maintained.

We have had the opportunity of observing two siblings with sporadic goitrous cretinism, which condition is known to arise from a genetically transmitted failure of thyroid hormone synthesis[2]. In our cases the metabolic block was found to be an inability of the thyroid to hold inorganic iodide and convert it to organic iodine (abnormally high uptake of iodine-131 during the first hours after the administration of the tracer, with a subsequent drop to abnormally low levels, low serum-protein-bound iodine-127; see Table 1). The resulting clinical manifestations were in both siblings a large, partly diffuse and partly nodular goitre, and severe myxœdema. The short-termed administration of massive doses of active thyroid principles (90 mgm. 'Triac' or equivalent doses of desiccated thyroid within 6–9 days) resulted each time in a protracted clinical remission lasting without additional therapy 6–7 months (altogether this 'stosstherapy' was performed five times). Studies of thyroid function performed at 2, 3 and 4 months of the therapy-free remissions revealed a practically normal pattern of thyroid function, thus incidentally also ruling out a fortuitious ingestion of thyroid substances[3,4].

In a third sibling, who only recently came under our observation and who was clinically and functionally perfectly like those previously studied, the same therapeutic procedure also resulted in a protracted and complete clinical remission which so far lasts 8 months. Thyroid function studies performed at early stages of the therapy-free remission revealed a low-normal pattern. The most striking and unexpected result of isotope studies was obtained at almost 6 months after the administration of the 'Triac stoss' (Table 1). The figures show that the thyroid gland which, according to universally accepted views must be the site of an inherited metabolic block at an early stage of hormone synthesis, was by that time not only capable of holding abnormally large amounts of iodine (6 days after the administration of the tracer, thyroidal collection was still 41 per cent) but also of converting it at a high rate to organic-bound iodine. That at least part of the protein-bound iodine released into the circulation was biologically active may be inferred from the clinical state of the patient, who was both euthyroid and agoitrous. Chromatographic study of the circulating iodine compounds could unfortunately not be undertaken, as the dose of iodine-131 administered was too small for this purpose. It will be the subject of further investigations.

This is, to the best of our knowledge, the first time that a genetically transmitted, that is, inborn, error of metabolism was at least temporarily repaired and converted into normal metabolic channels functioning at a higher rate even than normal. It is worthy of note that this effect was achieved by the extraneous administration of massive doses of sub-

Table 1

	Thyroidal uptake of iodine-131 (per cent of dose) 2 hr.	24 hr.	48 hr.	72 hr.	96 hr.	144 hr.	Urinary iodine-131 excretion (per cent of dose) 24 hr.	48 hr.	Serum iodine-131 precip. with trichloracetic acid (per cent of total activity) 24 hr.	48 hr.	72 hr.	Serum iodine-131 extracted with butanol (per cent of total activity) 48 hr.	72 hr.	Serum protein-bound iodine-127 (mcgm./100 ml.). Normal range: 3·5–5·5
Before therapy	60·0	30·0	15·0				22·5 ?	14·0						
6 months after 90 mgm. 'Triac' in 9 days	32·0	90·0	52·0	50·0	48·5	41·0	6·9	3·2	55	80	91	93·5	87·5	>1 3·2

stances chemically like the physiological end-product of the previously defective metabolic process.

Herman Zondek
Hannah E. Leszynsky

Department of Internal Medicine,
Bikur Cholim Hospital,
Jerusalem.

Joseph A. Stein

Radioisotope Laboratory,
Radium Institute,
Rothschild Hadassah University Hospital,
Jerusalem.

[1] Garrod, A. E., *Lancet*, ii, 142 (1908).
[2] Hutchison, J. H., and McGirr, E. M., *J. Clin. Endocrinol. and Met* **14**, 869 (1954).
[3] Zondek, H., Leszynsky, H. E., and Zondek, G. W., *Acta Endocrinol.*, **29**, 47 (1958).
[4] Zondek, H., Leszynsky, H. E., and Zondek, G. W., *Brit. Med. J.*, i, 340 (1959).

Effect of Wheat Gluten on the Peristaltic Reflex

Sensitivity to wheat or rye gluten is the essential mechanism in the pathogenesis of cœliac disease and idiopathic steatorrhœa. Such patients improve on a gluten-free diet and deteriorate on the re-introduction of gluten itself or its autoclaved and filtered peptic/tryptic digest into the diet[1]. In these diseases a disturbance of small intestinal function is a major factor[2].

The peristaltic reflex of the isolated intestine[3] was used to test the depressant activity of gluten and several of its fractions on intestinal motility. Perfusion of the autoclaved and filtered peptic/tryptic digest through the lumen did not produce any depression of this preparation. External administration, however, caused complete inhibition of longitudinal as well as circular muscle contraction. Movements returned while the material was still in the bath. This depression was also shown by an aqueous extract of gluten and was not affected by ultrafiltration. The ultrafiltrate of the aqueous extract was ten times as potent as the peptic/tryptic digest. All activity was abolished by acid hydrolysis. Incubation of the active material for a few minutes with small intestinal mucosa from the rat and with one specimen of human jejunal mucosa abolished the inhibitory effect.

The mechanism of this depressant effect of gluten fractions was studied with the help of the co-axially stimulated isolated guinea pig intestine[4]. The twitch response was markedly depressed for several minutes with either fraction. Assay of the acetylcholine output on the isolated guinea pig ileum treated with neostigmine and morphine[5] showed a significant depression with the addition of either material. In preliminary experiments, the synthesis of acetylcholine by small intestinal cholinacetylase[5] was not affected by the addition of the ultrafiltrate of the aqueous extract of gluten.

The conclusion is drawn that wheat gluten which is pathogenic in cœliac disease and idiopathic steatorrhœa contains a factor which depresses the peristaltic reflex of an isolated strip of intestine. This factor is heat-stable, resistant to peptic/tryptic digestion and not removed by ultrafiltration. It is sensitive to acid hydrolysis and digestion with small intestinal mucosa. It depresses acetylcholine output, but synthesis does not appear to be affected at moderate dosage-levels. It may therefore prevent release of acetylcholine from the inactive bound state.

R. Schneider
H. Bishop
B. Shaw*
A. C. Frazer

Department of Medical Biochemistry
and Pharmacology,
University of Birmingham.

* Present address: Boots Pure Drug Co., Ltd., Research Department, Chemistry Division, Island Street, Nottingham.

[1] Frazer, A. C., Fletcher, R. F., Ross, Constance, A. C., Shaw, B., Sammons, H. G., and Schneider, R., *Lancet*, ii, 252 (1959).
[2] Anderson, C. M., Frazer, A. C., French, J. M., Gerrard, J. W., Sammons, H. G., and Smellie, J. M., *Lancet*, i, 836 (1952).
[3] Bülbring, E., Crema, A., and Saxby, O. B., *Brit. J. Pharmacol.*, **13**, 440 (1958).
[4] Paton, W. D. M., *Brit. J. Pharmacol.*, **12**, 119 (1957).
[5] Feldberg, W., and Lin, R. C. Y., *J. Physiol.*, **111**, 96 (1950).

HÆMATOLOGY

Substance from Erythrocytes of Blood Group A

Blood group substances from erythrocytes have been claimed to be glycolipids, while those from secretions were described as mucopolysaccharides. It has been suggested that glycolipids from erythrocytes owe their blood group activity to the contamination by secretions like blood group substances[1]. The problem of identity or relationship between these two kinds of blood group substances may be solved only if their chemical and serological properties are directly compared.

The present communication describes the isolation and properties of a human blood group A substance from erythrocytes. Determinations of isoagglutination inhibition and hæmolysis (Forssman) inhibition tests were made using as a control the original sample of blood group A substance (kindly given by Prof. W. T. J. Morgan and Dr. W. M. Watkins of the Lister Institute, London) hereafter referred to as a 'standard A substance'.

Pooled, washed, human A erythrocytes were extracted with 4·05 vol. of 96 per cent w/w ethanol for 24 hr. at room temperature. The extract was Seitz-filtered and cooled to −7° C. A precipitate, 'crude A substance', which formed was centrifuged at −7° C., washed with acetone and dried in a vacuum. Its blood group activity, as measured by the isoagglutination inhibition test, was 2–5 per cent of the activity of the standard A substance; it did not contain O, H, Rh, M, N, P factors and exhibited no influenza virus hæmagglutination inhibition activity. Chemical analysis revealed 15·5 per cent reducing sugars as galactose, 2·6 per cent hexosamine, 3·4 per cent phosphorus, 2·0 per cent nitrogen; the glucosamine/galactosamine ratio[2] was 1 : 4.

The crude substance was extracted with acetone, ethyl ether, and petroleum ether successively, then dissolved in boiling methanol, filtered while hot, and the extract was cooled to 0° C. The precipitate formed ('precipitate M') contained 26·3 per cent reducing sugar, 5·0 per cent hexosamine, 1·4 per cent phosphorus. Its activity was about 10 per cent of that of the standard substance.

A sample of 'precipitate M' has been further purified by chromatography on a cellulose column. Two fractions emerged from the column: fraction I in

Table 1. Chemical Composition of A Preparations

Preparation	N	Sphingosine	Hexosamine	Reducing sugars	Galactosamine : glucosamine ratio	P	Blood group activity*	Forssman activity*
Precipitate M	2·2	—	5·07	28·0	5 : 1	1·38	10	50
Fraction I	—	—	4·82	26·0	—	1·4	5	25
Fraction II	2·3	1·4	9·4	47·6	1 : 1	0·3	25	100

* Expressed as percentage of the activity of standard A substance.

chloroform/ethanol/water, 16 : 4 : 1, and fraction II in chloroform/methanol/water, 5 : 15 : 1. They represented about 90 and 5 per cent of the chromatographed material, respectively. The properties of the two fractions are shown in Table 1. Fraction II was soluble in both water and organic solvents (pyridine, hot methanol, mixtures of chloroform and methanol). In water it forms a somewhat opalescent solution, exhibiting a considerable viscosity. This substance gave no reaction with *p*-dimethylaminobenzaldehyde described by Aminoff, Morgan and Watkins[3]. Galactose, glucosamine and galactosamine were identified in this material by means of paper chromatography in butanol/pyridine/water solvent. Fucose content of this material was 0·8–2·0 per cent. Fraction II may be further purified by extracting it with a large volume of hot 95 per cent acetone, then by cold precipitation from hot methanolic solution and finally by pyridine extraction and absorption on alumina, essentially after the method of Klenk and Lauenstein[4]. One of our best preparations obtained by the above methods contained 16·6 per cent hexosamine, 60 per cent reducing sugars, 2·7 per cent nitrogen and 1·37 per cent sphingosine nitrogen[5]. The sum of sphingosine and hexosamine nitrogen represented 98·8 per cent of the total nitrogen. The galactosamine/glucosamine ratio was 6 : 1[3]. Analytical values suggest that this material is hexosamine-sphingosine-trihexoside somewhat similar to preparations of red cell blood group substances described by Yamakawa and Suzuki[6]. The preparation was not tested for homogeneity, but fraction II did display two hexosamine-containing components in fractional solubility tests with methanol; the percentage ratio of the components amounted to 78 and 22 per cent. The activity of fraction II was about 12·5 per cent of the activity of standard substance. However, with a small number of anti-A sera, the erythrocyte substance was 10–20 times as active as standard A substance, but both appeared to be less active when tested against these particular sera than against the usual ones. The possibility cannot be excluded that these sera contained some unknown antibody against other components of the erythrocyte surface. The hæmagglutination inhibition activity has also been tested by Prof. W. T. J. Morgan against various anti-A reagents. Substances obtained from erythrocytes when tested against rabbit anti-human red cells sera were active in dilution of about 10^5, while when tested against rabbit anti-mucoid A substance sera showed activity of a lower order (about 10^4).

It is interesting to note that neither substances obtained from A red cells nor from O red cells contained O or H antigen.

The blood group activity of our preparations was not destroyed by treatment with hot 0·05 *N* sodium carbonate for 15 min., and no N-acetylhexosamine colour has developed on subsequent treatment with Ehrlich reagent[3]. This is exactly opposite to what has been found with substances obtained from body fluids[7]. When the erythrocyte substance was treated with hot hydrochloric acid, *p*H 2·3, for 8 hr. the kinetics of both disappearance of activity and appearance of N-acetylhexosamine colour were similar to those found for the mucoid A substance.

The above results point to the fact that blood group substance as obtained from human erythrocytes is a different chemical entity from the blood group substance as obtained from human body fluids.

J. Koscielak
K. Zakrzewski*

Department of Biochemistry,
Institute of Haematology,
Warsaw.

* Present address: United Nations Scientific Committee on the Effects of Atomic Radiation, New York 17.

[1] Kabat, E. A., "Blood Group Substances, their Chemistry and Immunochemistry", 121 (Academic Press, Inc., New York, 1956).
[2] Gardell, S., *Acta Chem. Scand.*, **7**, 207 (1953).
[3] Aminoff, D., Morgan, W. T. J., and Watkins, W. M., *Biochem. J.*, **51**, 379 (1952).
[4] Klenk, E., and Lauenstein, K., *Z. physiol. Chem.*, **241**, 249 (1952).
[5] McKibbin, J. M., and Taylor, W. E., *J. Biol. Chem.*, **178**, 29 (1944).
[6] Yamakawa, T., and Suzuki, S., *J. Biochem. Japan*, **39**, 393 (1952).
[7] Morgan, W. T. J., *Experientia*, **3**, 1 (1947).

Haptoglobin Types in 398 Blood Donors from Dakar (Senegal)

From results already published on the haptoglobin types in African populations, three points deserve attention. First, the Hp (1–1) type is very frequent. Secondly, the Hp (1–2) modified type, described by Connel and Smithies, is present much more often than in European populations[1]. Thirdly, the so-called ahaptoglobinæmic sera, which are so rare in the latter, were found in Africa with a frequency of up to 40 per cent[1,2].

In the present work, we have studied 398 serum samples from blood donors registered at the Centre Fédéral de Transfusion Sanguine, Dakar. The technique of electrophoresis in starch gel was that previously used by us[3], in a borate buffer at *p*H 8·3. In addition, a control in a phosphate buffer at *p*H 7·0 (ref. 4) was made on all the samples in which the characteristic bands of the Hp (1–2) or Hp (2–2) types were missing. It was thus very easy to distinguish the so-called ahaptoglobinæmic sera from those belonging to the Hp (1–1) type.

The observed frequencies are:

Hp (1–1)	148	(37·19 per cent)
Hp (1–2) normal	141	(35·43 per cent)
Hp (1–2) modified	44	(11·05 per cent)
Hp (2–2)	47	(11·81 per cent)
Special types	2	(0·50 per cent)
No haptoglobin detectable	16	(4·02 per cent)

The proportion of the sera in which no haptoglobin was detectable is very much lower in our results than that obtained by Allison *et al.*[2] and by Harris *et al.*[1]. In Gambia, Harris *et al.* found more than 40 per cent of such sera. On the other hand, Sutton *et al.*[5] did not specially seek the ahaptoglobinæmic types, but their figures suggest a low frequency, of the same order of magnitude as ours.

Sera which were weakly stained by the benzidine reagent were very frequent in the material we tested. Presumably, minor differences in the technique could have led us to classify them in the 'ahaptoglobinæmia' group. In such populations, if the size of this group is so largely dependent on the technique, it will be very difficult to make accurate comparisons from an anthropological point of view.

A more detailed report will be given elsewhere[6].

J. Moullec
J. M. Fine

Centre National de Transfusion Sanguine,
6 rue Alexandre-Cabanel,
Paris, 15.

J. Linhard

Hôpital Le Dantec,
Dakar.

[1] Harris, H., Robson, E. B., and Siniscalco, M., "Biochemistry of Human Genetics", Ciba Foundation Symposium (Churchill, London, 1959).
[2] Allison, A. C., Blumberg, B. S., and Rees, M., *Nature*, **181**, 824 (1958).
[3] Moullec, J., and Fine, J. M., *Nature*, **184**, 196 (1959).
[4] Laurell, C. B., *Scand. J. Clin. Lab. Invest.*, **11**, 18 (1959).
[5] Sutton, H. E., Neel, J. V., Livingstone, F. B., Binson, G., Kunstadter, P., and Trombley, L. E., *Ann. Hum. Genet.*, **23**, 175 (1959).
[6] Moullec, J., Fine, J. M., and Linhard, J., *Revue d'Hémat.* (to be published).

BIOLOGY

Translocation of Wild Animals as a Means of Game Control

A preliminary trial in the translocation of the herd of kob antelope (*Adenota kob thomasi*) at Lugari in Kenya was made in June of last year (Buechner, H. K., Harthoorn, A. M., and Luck, C. P., unpublished work). The herd in question numbers some 500 head, and is the only herd of kob in Kenya. Its existence in this number on the farm- and ranch-land of Lugari cannot be supported by the landowners. Moving part of the herd to other areas is the only alternative to destruction.

During the first eight days of the scheme early in March of this year, forty animals were darted, using one Capchur gun and Crockford syringes. Of this number 13 failed to go down; this was discovered to be due to a fault in loading, with resulting syringe blow-out between leaving the gun and entering the animal; three animals escaped on the first day due to faulty construction of the holding area; and three animals died during immobilization. Whereas deaths due to succinylcholine had not been reported previously in the course of immobilizing some sixty males, it appears that the female, possibly only the pregnant female, is more susceptible. After adding atropine to our succinylcholine solution, as is our routine practice with animals such as buffalo, no more deaths from this cause ensued. Among the first animals caught, two died from injuries caused by their efforts to break out of the stockade. Adequate thatching of the inner face of the perimeter stockade will possibly prevent this in the future, as will the presence of tame animals. Furthermore, these animals had not been tranquillized with 'Largactil'.

Twenty kob were ready at the end of the eight days for loading on to a truck to be moved to a game reserve 320 miles away. Of these, 18 were females, the greater number of whom were clearly pregnant; two were sub-adult males. The extreme tips of the young horns of the males were removed and the ends covered with strips of 'Elastoplast'. They were caught one by one by being driven into a crush, injected with 'Largactil' (chlorpromazine hydrochloride) and placed in the darkened truck interior. There they settled down immediately. The inner walls of the lorry had also been lined with grass.

The first attempt at moving these animals from the holding enclosure failed. The crush at that time opened into a small catching chamber where it was hoped to hold the animal by manual restraint while the injection was being made. This proved to be quite impracticable, and some injury was inflicted on the handlers. A modification whereby the animals ran through the crush into a specially constructed slatted box, where they could be tranquillized and afterwards moved to the truck, proved to be satisfactory. It was found convenient to drive the animals into the crush at dusk. Artificial lights were used to encourage the animal to move towards the slatted box. The animals were transported during the night to avoid overheating—an important factor in tropical climates.

In the first batch moved there were a dozen females and one male. All arrived safely at the new Meru Game Reserve, having travelled a distance of 320 miles.

The trial has indicated that the number of animals that can be caught by one gun or other projector, and moved per week, can be at least doubled with increased experience and improved equipment. This method of game control has now been shown possible. It is hoped that the principle of removing wild animals from contested areas will be used with increasing frequency instead of the destruction that has been practised up to date.

We wish to express our gratitude to the farmers in the Lugari area for their co-operation with us on this scheme. Equipment was supplied by the Kenya Game Department and the project has been assisted by a grant-in-aid from the Fauna Preservation Society, London. The succinylcholine chloride was kindly given by Messrs. Burroughs Wellcome (East Africa), Ltd., and the 'Largactil' by Messrs. May and Baker.

A. M. Harthoorn
J. A. Lock

Departments of Veterinary Physiology and
Medical Pharmacology,
University College of East Africa,
Kampala, Uganda.

J. MacKeand
(Warden)

Kenya Game Department.

Effect of Penicillin on the Maintenance of Rumen Oligotrich Protozoa

It has been shown previously[1,2] that sheep rumen *Entodinia* spp., principally *Entodinium caudatum*, could be grown *in vitro*, dividing every 48 hr. on a medium of salts, dried grass, rice starch, chloramphenicol and fresh or autoclaved rumen fluid, but that it was necessary to add fresh grass and rice starch to the medium every day. This communication describes the successful maintenance of these Protozoa in the presence of penicillin for periods up to 14 days without daily additions.

The substrate consisted of 3–4 ml. quantities of mineral salt solution *B* (see below) plus about 6 mgm. dried grass[1] and 0·2 ml. 10 per cent 'Difco' yeast-extract contained in cotton-plugged 7-ml. tubes (fitted with ground glass stoppers) and autoclaved at 10 lb./sq. in. for 20 min. Immediately after removal from the autoclave and cooling, the following additions were made aseptically: 0·2 ml. 1 per cent L-cysteine hydrochloride (neutralized with sodium hydroxide and Seitz-filtered just before use), 0·2 ml. 5 per cent sodium bicarbonate (Seitz-filtered), 0·25 ml. 6 per cent rice starch (British Drug Houses, Ltd., Poole, England; heated at 120° for 24 hr.), 0·8 ml. Protozoa-containing autoclaved rumen fluid and 0·4 ml. 25,000 U. penicillin *G*/ml. (sterile). The tubes were then inoculated, completely filled with sterile mineral salt solution *B* and sealed with flamed glass stoppers, taking care to exclude all air. The cultures were incubated at 38° without further additions to the medium. The mineral salt solution *B* contained per 100 ml.: K_2HPO_4, 0·50 gm.; KH_2PO_4, 0·39 gm.; NaCl, 0·050 gm.; $MgSO_4.7H_2O$, 0·007 gm.; $CaCl_2.6H_2O$, 0·007 gm.; CH_3CH_2COONa, 0·375 gm. The Protozoa-containing autoclaved rumen fluid was prepared from the rumen contents of a hay-fed Clun Forest sheep by straining through two layers of muslin and autoclaving under 95 per cent nitrogen + 5 per cent carbon dioxide in sealed McCartney bottles for 20 min. at 10 lb./sq. in.

The Protozoa (more than 90 per cent *Entodinium caudatum*) for inoculation were prepared from cultures which were growing in the presence of rice starch, grass, chloramphenicol and autoclaved rumen fluid under the condition *C*2 [2] and which had been last diluted 48 hr. previously. Under these conditions the Protozoa formed a layer at the bottom of the tube, and the grass formed a scum on the surface. This surface scum was removed and then the residual medium plus the Protozoa centrifuged at 400*g* for 1 min. on an angle-head centrifuge, the organisms washed twice on the centrifuge in 10 ml. of sterile mineral salt solution containing 0·03 per cent L-cysteine and inoculated. The initial number of Protozoa was usually 3,000–20,000/ml.

Rough viable counts on the number of bacteria present in the protozoal cultures were made by carrying out serial tenfold dilutions in cotton-plugged test-tubes containing 10-ml. quantities of the following medium: mineral salt solution[1] without the sodium acetate containing 0·5 per cent 'Difco' yeast extract, 0·5 per cent glucose, 0·5 per cent 'Difco Bacto-tryptose', 0·35 per cent sodium lactate and 4·0 per cent Protozoa-containing autoclaved rumen fluid (centrifuged to remove the solid matter), autoclaved at 10 lb./sq. in. for 20 min. The cultures were incubated aerobically at 38° until no further growth was observed (about 4 days); the addition of 0·05 per cent L-cysteine and incubation in anaerobe jars under 95 per cent hydrogen + 5 per cent carbon dioxide (without catalyst) did not increase the number of viable bacteria found in penicillin-treated cultures.

Under the cultural conditions described the number of Protozoa increased for 3–7 days (Fig. 1), and the omission of the yeast extract or Protozoa-containing autoclaved rumen fluid reduced or prevented the growth of the Protozoa although they remained alive for up to 7 days. Similar results with a doubling in the number of Protozoa in 3–7 days were obtained from inocula of 2,000–40,000 Protozoa/ml. and in the best experiments fivefold increases

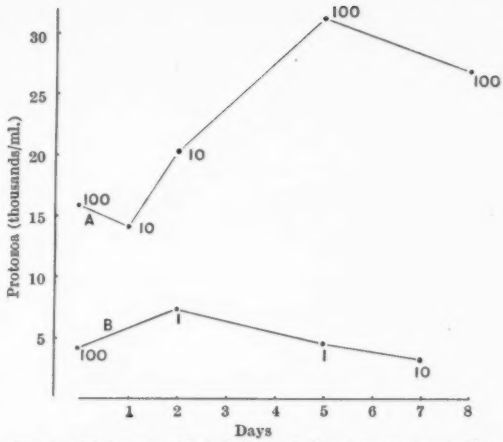


Fig. 1. Maintenance of *Entodinia* spp. in the presence of penicillin, without daily additions, under the conditions described using two levels of inoculum. The figures at each point indicate in thousands the approximate number of bacteria per ml. in the complete culture

were obtained in 3 days. From the third–seventh day onwards, depending on the experiment, the number of Protozoa declined steadily until they were usually dead by the twelfth–fourteenth day, although some occasionally persisted for 16–17 days.

Fig. 1 shows that the number of viable bacteria present in the complete protozoal culture containing the Protozoa was 10^3–10^5/ml., but in approximately half the experiments the number of bacteria present during protozoal growth was 10^6–10^7/ml. However, in almost all experiments the rice starch was metabolized only slowly and remained as a white deposit on the bottom of the tube throughout. This is in contrast to the results reported previously[2] for growth in the presence of chloramphenicol, where all the starch disappeared within 24 hr. and the number of viable bacteria was 10^7/ml. (as determined by the above viable count method); it shows that the number of viable bacteria could be reduced to 1 per cent or less. Nevertheless, since the Protozoa were not broken before the viable counts were carried out, it is possible that, in experiment *A* (Fig. 1) at least, the Protozoa contained many bacteria. It seems probable that in the present experiments the penicillin inhibited the growth of the starch-digesting bacteria, and that the starch remained for the Protozoa to engulf and metabolize. The numbers of viable bacteria reported are not necessarily an accurate estimate of the number actually present, but since there is no one medium which will grow all rumen bacteria, the results may be taken to indicate that the numbers of some of the more easily grown bacteria can be markedly reduced without affecting protozoal growth. Further experiments are in progress in an attempt to reduce the numbers of viable bacteria to still lower levels and to obtain Protozoa that contain no bacteria.

An effect of fresh rumen fluid on the Protozoa was shown in the following experiment. A protozoal culture which was declining in numbers was diluted with an equal volume of fresh complete medium and divided between two tubes. One drop of fresh rumen fluid[1], from which the Protozoa had been removed, was added to one tube; growth of the Protozoa was resumed in that tube but not in the other. In the

presence of the fresh rumen fluid the Protozoa divided once or twice in three days without any daily additions, whereas in its absence the numbers declined by 50 per cent in three days.

I wish to thank Miss J. M. How for technical assistance.

G. S. Coleman

Biochemistry Department,
Agricultural Research Council
Institute of Animal Physiology,
Babraham,
Cambridge.

[1] Coleman, G. S., *Nature*, **182**, 1104 (1958).
[2] Coleman, G. S., *J. Gen. Microbiol.*, **22**, 555 (1960).

Protandry and Self-Fertilization in the Calyptraeidae

Orton[1] suggested that protandrous animals might be self-fertilizing and that this would be advantageous for the spread of a species. He concluded that *Crepidula fornicata* was self-fertilizing because he found an isolated female guarding veliger larvæ. I have kept single *Crepidula* in aquaria and they have laid fertilized spawn two to three months later. Chipperfield[2] found no unfertilized eggs but he examined only unbroken chains from a densely populated area. Wilczynski[3] has recently said that the typical chains are feeding communities, not breeding associations and that copulation is effected with additional or visiting males. In *Calyptraea chinensis* (L.) males and females begin to associate seven months before spawn is laid[4]. Females probably store foreign sperms for long periods. Evidence for self-fertilization in *Crepidula* is therefore still lacking.

Calyptraea chinensis is a protandrous hermaphrodite and might be self-fertilizing as sperms and ova are found together in the gonad. However, many functional females guard unfertilized eggs. These eggs are more orange than the normal 1–8 cell embryos (stage 1) (ref. 4), lack a definite shape and fertilization membrane and are very fragile. When kept in the laboratory in finger bowls of sea water, these eggs slowly disintegrated into masses of yellow globules whereas normal stage-1 embryos developed so far as the veliger stage. Unfertilized eggs left undisturbed beneath the parent on glass did not develop.

The percentage of unfertilized spawn varied in different years. There was an inverse relationship between association of males with females and the percentage of unfertilized spawn laid the following summer (Table 1). The total number of associated females was undoubtedly higher than that shown, especially in the winter of 1953–54. The period of association was sometimes as short as overnight in laboratory experiments although many associations last for several months in the laboratory and in the Yealm Estuary. I never saw copulation, nor can I find an account of it. The possibility of small numbers of self-fertilizing animals is not excluded. Table 1 shows the percentage of females guarding unfertilized eggs. Females were found which guarded both embryos and unfertilized eggs, even in the same capsule. These were classed as fertile spawn even when only one embryo was found. The total number of unfertilized eggs is therefore greater than Table 1 suggests.

Table 1. Association of *Calyptraea chinensis* and Subsequent Percentage of Unfertilized Eggs in the Yealm Estuary

Percentage of functional females associated in the winter		Percentage of functional females with spawn, guarding unfertilized eggs	
1952–53	unknown	summer 1953	7
1953–54	24	summer 1954	30
1954–55	<5	summer 1955	70

C. chinensis has no free-swimming veliger larva and the hatched animals do not move far. Each male seeks a female and, after association with her, departs to find a smooth surface for his own permanent settlement and change of sex. The surface may be a stone, shell or glass; the only rough surface on which I have found an animal was the ribbed outer shell of *Cardium edule*. The number of suitable surfaces is limited and the stone already occupied by a female must be suitable for a male after association. The number of stones with two or more animals might be greater than that expected by chance. Gregariousness would increase the chance of association and the number of fertile spawnings.

Three samples collected in July, August and September before the main period of association were examined. The numbers of animals on each stone (Table 2) showed no evidence of gregariousness when compared with the expected Poisson distribution.

Table 2. Numbers of *Calyptraea chinensis* found on Stones in the Yealm Estuary

No. of associated females	No. of animals not associated	Nos. of stones bearing unassociated animals									
		1	2	3	4	5	6	7	8	9	Total
21	1,168	762	110	40	7	2	2	1	0	1	925

Calyptraea chinensis in the Yealm Estuary was neither self-fertilizing nor gregarious. It is doubtful whether the protandrous Calyptraeidae are self-fertilizing, and if some animals are, the number of embryos so produced is probably small.

H. V. Wyatt

Department of Bacteriology,
The Medical School,
Leeds, 2.

[1] Orton, J. H., *Nature*, **169**, 279 (1952).
[2] Chipperfield, P. N. J., *J. Mar. Biol. Assoc. U.K.*, **30**, 49 (1951).
[3] Wilczynski, J. Z., *Bull. Biol.*, **109**, 353 (1955); *J. Exp. Biol.*, **36**, 34 (1959).
[4] Wyatt, H. V., *Ann. Mag. Nat. Hist.* (in the press).

Suppression of Cytoplasmic Division in *Amoeba proteus*

Cytoplasmic division in *Amoeba proteus* can be suppressed by the application of strong light during the division process[1]. The same can be achieved as follows. Division is allowed to proceed undisturbed until nuclear division is complete. When the cell becomes elongated and the division furrow appears, slight pressure with a glass needle is applied for short intervals alternately on each one of them, thus shifting parts of the liquid endoplasm back and forth from one prospective daughter cell into the other. After about 7–10 min. of such treatment, without having completed the cleavage the cell resumed its normal interphase appearance. The surface, which

had been covered with blebs, becomes smooth, pseudopodia are formed, and the cleavage furrow gradually disappears. Pressure applied for the same length of time before the completion of nuclear division does not prevent either nuclear or cytoplasmic division. Once the furrowing process is suppressed no cytoplasmic division occurs before the next full cell division about 20–28 hr. later.

The observation that the prevention of cytoplasmic division by pressure applied for a minimum time of 7–10 min. is sufficient to postpone it for one full cellular cycle suggests that the completion of chromosome duplication has itself a reversing influence upon the factors involved in cytoplasmic division. The minimum time which this influence requires to become effective is provided in the experiment by the artificial retardation of the furrowing process. If the initiation of both nuclear and cytoplasmic division were controlled by the ratio between utilization and production of chemically bound energy[2–4], the increased rate of energy-utilizing macromolecular synthesis after mitosis[5–7] could be the mechanism for this reversal.

EDMUND GUTTES
SOPHIE GUTTES

Department of Biology,
Brown University,
Providence 12,
Rhode Island.

[1] Prescott, D. M., "Rhythmic and Synthetic Processes in Growth", edit. by Rudnick, D., 59 (Princeton University Press, 1957).
[2] Plesner, P. E., *Biochim. Biophys. Acta*, **29**, 462 (1958).
[3] Swann, M. M., *Cancer Res.*, **17**, 727 (1958).
[4] Guttes, E., and Guttes, S., *Science*, **129**, 1483 (1959).
[5] Prescott, D. M., *Exp. Cell Res.*, **9**, 328 (1955).
[6] Mitchison, J. M., *Exp. Cell Res.*, **13**, 244 (1957).
[7] Mitchison, J. M., *Exp. Cell Res.*, **15**, 214 (1958).

Albinism in an American Population of the Shore Crab, *Carcinus maenas* (L.)

THE common shore or green crab, *Carcinus maenas* (L.), is a widely distributed predator in inshore areas on both sides of the Atlantic. The ecological importance of the green crab, its status as a predator on commercial shellfish, and its extensive use in laboratory studies warrant a preliminary report on a recently noted abnormality found in a population of this species near Woods Hole, Massachusetts.

Two female *Carcinus maenas* with abnormal coloration were discovered by me in the summer of 1958 at Menemsha Creek, Martha's Vineyard Island, Massachusetts. In one specimen the right cheliped was entirely lacking pigment, appearing chalky white. The second specimen was similarly affected in all segments of a walking leg. The crabs, which had mated prior to capture, were isolated in running sea water at the Massachusetts State Lobster Hatchery and Research Station, and in November of 1958 they both became ovigerous. The white-clawed individual lost all her eggs during confinement; but the last of these were well developed by the time they became unattached. The second crab retained a part of the egg mass to the hatching stage. During March 20–30, 1959, slightly more than 700 eggs hatched from this female, 15 of them yielding larvæ totally lacking pigment except for the eyes. This group, slightly less than 2 per cent, were completely transparent and very readily separable from their siblings. Had they survived they probably would have become totally white adults. Relatively small amounts of white such as present on the parent crab would have been indistinguishable in the larval stages, and thus it is possible that some of the 'normal' larvæ also would have exhibited some albinism had they attained the adult form.

An attempt was made to rear all the larvæ but *Artemia* nauplii provided as food were apparently too large for the larvæ to utilize and other foods were not available at the time. Within 23 days of initial hatching all larvæ had died from starvation or other adverse cultural conditions, but there was no apparent tendency for albino larvæ to succumb more quickly than the others.

Discovery of several additional albino adults in the tidal creeks near the Lobster Hatchery some 10 miles from Menemsha indicated that the anomaly was not restricted to a single locality. Indeed, John Ropes of the Narragansett Marine Laboratory has since found partially albino green crabs in Rhode Island waters and even in Plum Island Sound, Massachusetts, north of Cape Cod.

To determine the frequency of occurrence of this abnormality in a natural population a trapping survey was undertaken during the summer months of 1959, near the Lobster Hatchery. The traps used were of 1-in. chicken wire mesh, and very young crabs were not retained. The results, therefore, are based only on adults and large juveniles. Prior to May 26, 1959, a total of 5 albino crabs had been captured in Martha's Vineyard waters. Between May 26 and July 31, 1959, a total of 1,595 green crabs was trapped of which 45, or 2·9 per cent, were partial albinos. The degree of albinism exhibited varied considerably. Thirty-one specimens had only one dactyl affected, whereas some specimens had several entire appendages white. In two specimens a white maxilliped was found, and several individuals had white sternal plates. At least two specimens were irregularly mottled on the carapace and other portions of the body. Specimens which moulted in captivity showed the same degree of albinism after moulting as before. There was no indication that the abnormal coloration was the result of injury or regeneration.

The incidence of 3 per cent reported here for an adult population may be lower than the frequency for the population as a whole, for trapped animals often had one or more appendages missing which would tend to reduce apparent incidence. If selective predation tends to eliminate those individuals showing large white areas, the adult incidence is probably less than in a juvenile population.

The wide variation in degree of albinism suggests more than one gene may be responsible for inheritance and/or exhibition of the character, but controlled laboratory matings will be necessary to study the inheritance of this condition in more detail.

At the time the data were collected I was employed by the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Milford, Connecticut. I wish to thank Dr. V. L. Loosanoff, director of the Milford Laboratory, for permission to undertake this study.

ANTHONY J. PROVENZANO, JUN.

Marine Laboratory,
1 Rickenbacker Causeway,
Miami 49,
Florida.

Chordotonal Organs in Crustacea

There is a series of proprioceptor organs in the joints of the walking legs of decapod Crustacea, each consisting of a strand of elastic connective tissue with which are associated bipolar sensory nerve cells. These organs have been mentioned by Alexandrowicz and Whitear[1] and by Alexandrowicz[2]; work on their physiology has been published by Burke[3], Wiersma and Boettiger[4] and by Wiersma[5]. An electron microscope study of these organs in *Carcinus maenas* has now shown that they are chordotonal organs; the distal processes of the sensory cells are associated with scolopales.

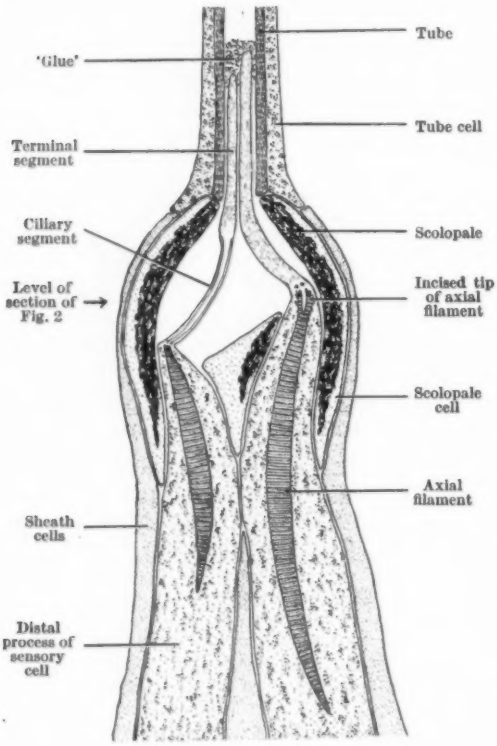


Fig. 1. Diagrammatic longitudinal section of a heterodynal scolopidium of the propodite-dactylopodite chordotonal organ, not to scale

In the organ spanning the propodite-dactylopodite joint each scolopidium receives the distal processes of two sensory cells; these are dissimilar in their fine structure. Following Debauche[6], who described scolopidia with paired sensory cells in certain insect chordotonal organs, such a scolopidium may be described as *heterodynal*. The structure is illustrated diagrammatically in Fig. 1. All the parts shown are embedded in the connective tissue of the strand; the nerve cell bodies may lie within the strand, or alongside it. Proximally, the distal processes of the sensory cells are wrapped in sheath cells which separate them from the connective tissue of the strand. Where a pair of distal processes become associated they are separated by a sheath cell, but after a certain distance this withdraws from between them, so that the cell membranes of the two sensory cells are in apposition, separated only by a 200–300 Å. gap. The two processes then enter the base of the scolopale, and become separated again by an intrusive projection of the scolopale cell. The scolopale itself is an intracellular organ consisting of an agglomeration of fibrous material which is markedly electron-dense. The scolopale cell encloses a space, 2–5μ across, which is presumably filled with fluid during life. Within the scolopale, the distal processes of the sensory cells narrow, and at first lie against the wall. They then change their structure and pass across the scolopale cavity to enter a tube, the lumen of which is continuous with the scolopale space. This tube, which corresponds to the 'terminal bundle' or 'terminal fibre' of classical descriptions of scolopidia, is an extracellular organ, presumably formed by a pair of cells which lie on either side of it. The walls of the tube consist of an amorphous substance which is vacuolated at intervals. The tube continues distally some way beyond the ends of the distal processes of the sensory cells, but eventually ends within the connective tissue strand; it does not reach so far as the exoskeleton.

As the distal processes of the sensory cells approach and enter the scolopale, each contains an *axial filament*, which is a rod about 0·5μ in diameter, tapering at the ends. It has transverse striations with a total interval of about 800 Å. Distally the axial filament ends where the sensory cell process leaves the wall of the scolopale; mitochondria occur in the cytoplasm of the cell process up to this point, but not beyond it. One of the two dissimilar sensory cell processes (that on the left in the diagram) as it passes into the lumen of the scolopale acquires a fine structure somewhat like that of a cilium, with nine peripheral microfilaments; there are, however, no central microfilaments. This part of the sensory cell process, the *ciliary segment*, is about 0·3μ in diameter. Before leaving the scolopale, the distal process thickens and loses the ciliary structure; instead of nine peripheral filaments it contains numerous microtubules, each about 200 Å. across. This part of a sensory cell process may be called the *terminal segment*. In the second sensory cell process (on the right in the diagram) the axial filament is longer than in the first cell, and extends somewhat farther up the scolopale wall, often partially wrapped by a ridge of the scolopale. At its distal end this axial filament becomes incised and vacuolated, so that in transverse section its extreme tip appears as an annulus with radiating buttresses. The ciliary segment as such is lacking, although in some cases there are indications of a ninefold structure immediately beyond the tip of the axial filament. As it crosses the lumen of the scolopale, the cell process has the structure of a terminal segment, with microtubules.

Fig. 2 is an electronmicrograph of a transverse section of a heterodynal scolopale showing the ciliary segment of one cell process and the incised tip of the axial filament of the other.

Both terminal segments run for a certain distance into the tube. Near their ends they become surrounded by an ill-defined substance which in Fig. 1 is referred to as 'glue', in consequence of its supposed function of fastening the terminal segments into the tube. One of the distal processes generally extends slightly farther than the other, but they both end within the 'glue'; more distally the tube appears empty.

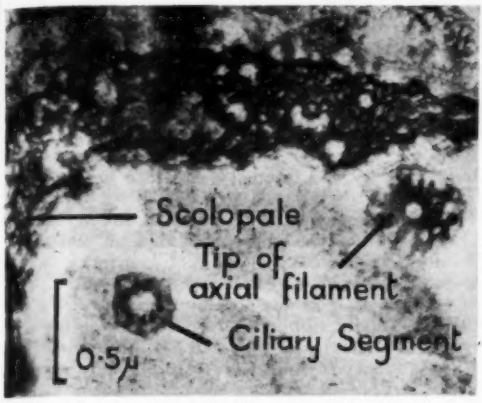


Fig. 2. Electronmicrograph of a transverse section of part of a scolopale of the propodite-dactylopodite organ; the level of the section is indicated in Fig. 1. Specimen fixed in osmium tetroxide, stained with phosphotungstic acid, and embedded in 'Araldite' epoxy-resin

All the scolopidia seen in the propodite-dactylopodite chordotonal organ have been heterodynal. According to Wiersma and Boettiger[4], the distal cells are 'position' and the proximal cells 'movement' receptors; no morphological differences between the scolopidia in the two positions have been detected, except in the size of the cell bodies.

There are two chordotonal organs associated with the carpopodite-propodite joint; *CP* 1 does not cross the joint, *CP* 2 does. All the scolopidia seen in *CP* 1 have been heterodynal, wherever situated. In *CP* 2, on the other hand, all the scolopidia seen have had associated with them only one sensory cell; it is proposed to refer to scolopidia of this type as *monodynal*. In all the cases seen, the distal process has been of the type with a ciliary segment. Apart from the lack of a second cell process, the structure of a monodynal scolopidium is as described above.

The organs in the meropodite have not yet been investigated with the electron microscope. The organ of the coxo-basipodite joint, *CB*, has scolopidia with paired distal processes, which are similar to one another, both being of the type with a ciliary segment. Following Debauche[6], such scolopidia are *isodynal*. Their structure otherwise resembles that of the heterodynal scolopidia.

Many of the structures described in these crustacean scolopidia, for example, the scolopale, axial filament and ciliary segment, may be compared directly with those in the scolopidia of the auditory organs of *Locusta migratoria*, recently described by Gray[7].

Any discussion of the functions of the types of scolopidia described above is speculative. So far as the propodite-dactylopodite and carpopodite-propodite organs are concerned, it would not be inconsistent with the results of Wiersma and Boettiger[4] and of Wiersma[5] to suppose that, in the heterodynal scolopidia, one sensory cell responds to stretching of the terminal segment, and the other to its slackening. The apposition of the two distal processes, proximal to the scolopale, suggests that they are capable of interacting in some way, perhaps of modifying one another's response. The presence of monodynal scolopidia in *CP* 2 would be consistent with Wiersma's report that the response of this organ is commonly to movement in one direction only. There are no published results on the responses of the coxo-basipodite organ, so that nothing can be said about the functions of isodynal scolopidia; it should be noted, however, that this is the only chordotonal organ of the series investigated which is not attached to a muscle tendon.

Various anomalies have been seen, particularly in the structure of non-ciliary processes of the heterodynal scolopidia, for which no explanation can be given as yet. The receptor organs at the bases of the legs of decapods, described by Alexandrowicz and Whitear[1] and by Alexandrowicz[2], are also being investigated by electron microscopy. It need only be mentioned at present that the muscular receptor organ and the innervated elastic strands are not chordotonal organs, and show none of the elaborations of structure described here.

MARY WHITEAR

Department of Zoology,
University College, London.

[1] Alexandrowicz, J. S., and Whitear, M., *J. Mar. Biol. Assoc. U.K.*, **36**, 603 (1957).
[2] Alexandrowicz, J. S., *J. Mar. Biol. Assoc. U.K.*, **37**, 379 (1958).
[3] Burke, W., *J. Exp. Biol.*, **31**, 127 (1954).
[4] Wiersma, C. A. G., and Boettiger, E. G., *J. Exp. Biol.*, **36**, 102 (1959).
[5] Wiersma, C. A. G., *J. Mar. Biol. Assoc. U.K.*, **38**, 143 (1959).
[6] Debauche, H., *Cellule*, **44**, 45 (1935).
[7] Gray, E. G., *Phil. Trans.*, B. (in the press).

Effects of Light and Darkness on the Rhythm of Output of Carbon Dioxide of Excised *Bryophyllum* Leaves

IT has been shown by Wilkins[1,2] that if excised leaves of the succulent plant *B. fedtschenkoi* are maintained in darkness, at a constant temperature of 26° C. and in an air-stream initially free of carbon dioxide they exhibit a 22·4-hr. rhythm in their rate of output of carbon dioxide. Furthermore, it was found that continuous illumination inhibited the rhythm, which recommenced when darkness was restored. A more detailed investigation of the light inhibition of the rhythm has been made by illuminating leaves for a few hours at various positions in the cycle.

If leaves are illuminated for 3 (Fig. 1*A*) or 6 hr. at an intensity of 3,000 lux between the peaks the phase is reset so that the first post-treatment peak occurs approximately 19 hr. after the end of the treatment. The degree of phase shift is therefore determined not by the duration of the treatment but by the time at which it terminates. Illumination for 1 hr., even at an intensity as high as 20,000 lux, has little or no effect upon the phase. On the other hand, up to 5 hr. illumination at an intensity of 3,000 lux applied at the crest of a peak did not reset the phase (Fig. 1*B*). Thus, the phase of a rhythm persisting in leaves in darkness varies in its sensitivity to a 3-hr. light treatment; it is reset by a treatment applied between, but not at the crests of, the peaks.

Over the range 8–3,000 lux, the intensity of illumination during a 6-hr. light treatment applied between the peaks has no effect on the efficiency with which that treatment resets the phase; the phase delay is determined by the time at which darkness is restored. At an intensity of 2 lux, however, the phase delay is equal to the duration of the treatment.

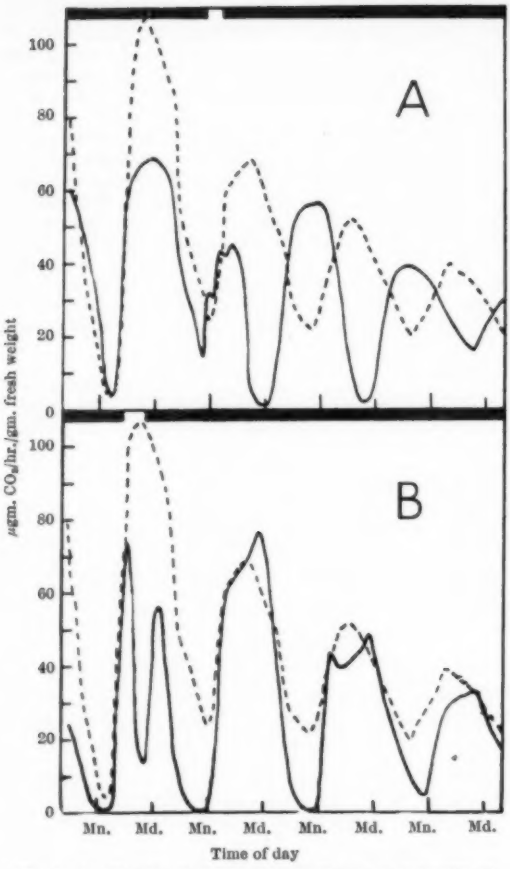


Fig. 1, *A*. Showing that 3-hr. illumination at an intensity of 3,000 lux, applied between the peaks, resets the phase of a rhythm persisting in darkness and at 26° C. *B*, showing that 5-hr. illumination at 3,000 lux applied at the crest of the peak does not reset the phase. Illumination programme shown by the bar above each figure. Ordinates: μgm. carbon dioxide/hr./gm. fresh weight. Abscissæ: Time of day, Mn. = midnight, Md. = noon. Control experiment in continuous darkness throughout shown by the broken lines

Wave-lengths of light greater than 565 mμ are responsible for inducing a phase shift. A 6-hr. red light treatment at an intensity of 850 ergs/cm.²/sec. applied between the peaks resets the phase in a manner similar to a 3,000-lux white light treatment, whereas 6-hr. illumination with blue light (below 525 mμ) at an intensity of 10,860 ergs/cm.²/sec. has no effect upon the phase. Moreover, continuous red light completely inhibits the rhythm, which recommences in blue light.

Clearly, whether or not a light treatment resets the phase of the rhythm depends on its wave-length, duration and intensity, and the time in the cycle at which it is administered.

It was previously observed that continuous illumination strongly inhibits the rhythm; but experiments carried out to determine the effect of changing the intensity of light to which leaves were exposed revealed that a rhythm is initiated in illuminated leaves if the intensity is reduced, either suddenly or gradually, by at least 80 per cent. The effect of a given intensity on the rhythm depends, therefore, on the intensity by which it is immediately preceded. For example, exposing leaves to an intensity of 500 lux inhibits a rhythm which was previously persisting in darkness (Fig. 2*A*), but initiates a rhythm in leaves which had previously been exposed to the higher intensity of 2,500 lux (Fig. 2*B*). A rhythm induced in this way in illuminated leaves will persist so long as a rhythm in darkened leaves and its phase is determined by the time at which the intensity is reduced. Over the range 0–500 lux, the period is unaffected by the intensity of white light to which the leaves are exposed.

Further experiments were carried out to determine whether or not the phase of a rhythm persisting in illuminated leaves was reset by interrupting the illumination with a few hours darkness and, if this was so, whether it was equally responsive to a short dark treatment applied at different positions in the cycle. A rhythm was initiated by illuminating leaves at an intensity of 3,000 lux for 13 hr. and then reduc-

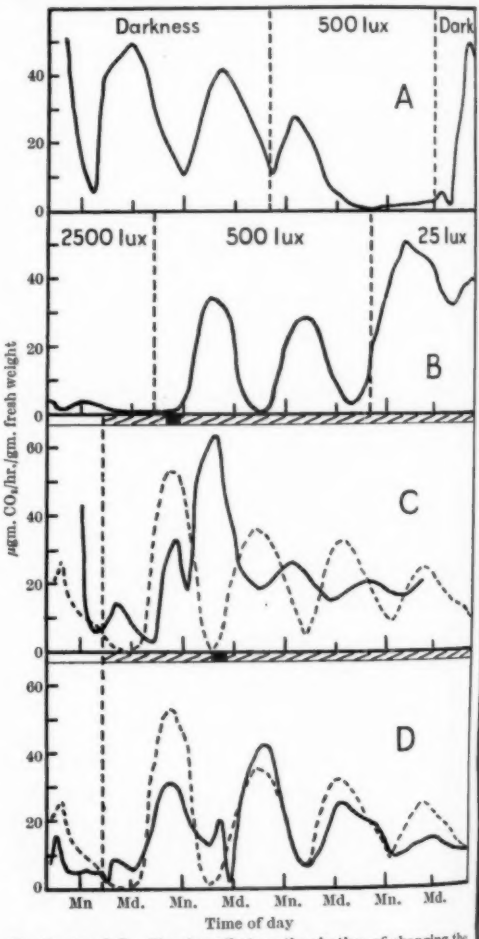


Fig. 2. *A* and *B*. Showing effect on the rhythm of changing the intensity of illumination to which the leaves are exposed. An intensity of 500 lux inhibits a rhythm in leaves previously exposed to darkness (*A*), but initiates a rhythm in leaves which were previously exposed to an intensity of 2,500 lux (*B*). *C* and *D*, showing that the phase of a rhythm in leaves illuminated at an intensity of 100 lux (hatched area in the illumination programme bar) is reset by 3 hr. darkness applied at the crest of a peak (*C*) but not between the peaks (*D*). Control experiment in 100 lux throughout shown by the broken lines. Unshaded area of illumination bar indicates that leaves were exposed to an intensity of 3,000 lux

ing the intensity to 100 lux (broken curves in Figs. 2*C* and 2*D*). The phase is reset by darkening leaves for 3 (Fig. 2*C*), 6 or 9 hr. at the crest of a peak. The amount of phase shift is determined by the duration of the treatment, increasing to a maximum with 9-hr. darkness. On the other hand, the phase is unaffected by darkening leaves for 3 (Fig. 2*D*) or 6 hr. between the peaks. The phase of a rhythm persisting in illuminated leaves varies in its sensitivity to a 3-hr. dark treatment, being reset by a treatment applied at the crests of, but not between, the peaks. This variation is in the opposite sense to that of the phase of a rhythm in darkened leaves to a 3-hr. light treatment.

The phase of a rhythm in illuminated leaves is, however, reset when the light is permanently extinguished at a point between, or at the crests of, the peaks. Thus, while 6-hr. darkness applied between the peaks does not affect the phase, continuous darkness commencing at a similar time induces a phase shift.

The effects of light and darkness on the rhythm differ in two respects. If leaves having a rhythm persisting in light are exposed to continuous darkness only the phase is shifted, the rhythm is not inhibited as it is when leaves which have been kept in darkness are exposed to continuous light. Further, the minimum duration of light treatment required to induce maximum phase shift in a rhythm persisting in darkness is less than 3 hr., whereas more than 6-hr. darkness is required to induce maximum phase shift in leaves having a rhythm persisting in light.

In general, the reactions of the endogenous rhythm in *Bryophyllum* to changes in conditions of illumination closely resemble those of the rhythm of luminescence in *Gonyaulax polyedra*[3]. A more complete description of this work and a detailed comparison of the results with those of other authors will be published elsewhere.

Malcolm B. Wilkins

Botany Department,
King's College,
University of London,
68 Half Moon Lane,
S.E.24. March 21.

[1] Wilkins, M. B., Ph.D. thesis, University of London (1958).
[2] Wilkins, M. B., *J. Exp. Bot.*, **10**, 377 (1959).
[3] Hastings, J. W., and Sweeney, B. M., *Biol. Bull.*, **115**, 440 (1958).

ENTOMOLOGY

Recognition of Nulliparous Mosquitoes without Dissection

During the age-grading of female mosquitoes it frequently happens that a large proportion of the dissecting time is devoted to the recognition of those that are nulliparous, when it is usually only the parous ones which require detailed examination. Such a difficulty is encountered to a marked degree in large samples of forest mosquitoes in Uganda, of which more than 95 per cent may be nulliparous. It is therefore desirable to establish means whereby as many nullipars as possible can be recognized without dissection. The use of two external characters for age-grading mosquitoes has been suggested previously[1,2], but only recently have techniques become available[3] whereby their reliability can be adequately checked. The work reported here was undertaken to determine whether these and two other external characters could be used with confidence to distinguish nullipars of certain African mosquitoes. The condition of each mosquito was checked by dissection of the ovaries[4]. Results show that in certain species the use of these characters can enable up to 90 per cent of nullipars to be recognized, thereby effecting a great economy in the age-grading of samples.

External wear. Variation in external wear was suggested as a means of age-grouping by Perry[1]. This character can be valuable if its use is restricted to recognizing only those females so fresh as to be certainly nulliparous. Once the minimum amount of wear associated with the first oviposition has been assessed, thereafter all individuals showing less wear can be classified as nulliparous. To establish the appropriate level of minimum wear in *Mansonia* (*Coquillettidia*) *metallica* Theo. and *M.* (*C.*) *fraseri* Theo. about 500 females of each species were first examined and dissected, and then reliability trials were conducted. Subsequent errors were extremely small. Of those classified as 'nulliparous', 8/938 (0·9 per cent) of *M.* (*C.*) *metallica* and 1/946 (0·1 per cent) of *M.* (*C.*) *fraseri* were parous; whereas among those classified as 'doubtful' 97/225 (43·1 per cent) and 60/143 (42·0 per cent) were parous, respectively. It has been found, moreover, that by adopting a slightly more severe criterion of minimum wear and achieving a greater familiarity with the species concerned, these errors can be reduced still further. In these samples the number of nulliparous mosquitoes dissected unnecessarily was reduced from 93 to 10 per cent. The amount and type of wear that is critical must be assessed independently for each species. Denuding of the abdominal sternites is the best guide in *Mansonia* (*Coquillettidia*), whereas wing fray is more reliable in *Mansonia* (*Mansonioides*) *africana* Theo., *M.* (*M.*) *uniformis* Theo. and *Aëdes*.

Parasitic mites. Gillett[2] suggested that hydrachnid mites could be used to age-grade swamp-breeding mosquitoes. Subsequent attempts to determine their reliability by dissection[3,5] have shown that, although the great majority of infested females are nulliparous, mites occasionally occur on parous ones also. In the present work it has been found that, although in some species more than 30 per cent of parous mosquitoes may carry mites, in nearly every case the latter are either dead or else not hydrachnids. Female mosquitoes which bear living hydrachnids are almost always nulliparous (Table 1). It is considered likely that the few exceptions recorded in Table 1 were due to initial failure to recognize those mites which were dead. In *M.* (*C.*) *fuscopennata* Theo., for example, hydrachnid mites die on at least 5 per cent of infested females before their first oviposition, and thereafter

Table 1. Infestation of Mosquitoes with Living Hydrachnid Mites

Species	Nulliparous		Parous	
	Total examined	Percentage bearing hydrachnids	Total examined	Percentage bearing hydrachnids
M. africana	266	65·8	179	2·8
M. fuscopennata	1,594	52·1	676	2·5
M. uniformis	39	43·6	36	2·8
C. annulioris	366	14·2	330	0·3
M. metallica	3,994	10·4	384	—
M. aurites gp.	198	8·6	35	—
M. fraseri	4,944	8·3	410	—
M. maculipennis	197	4·6	20	—
M. pseudoconopas	1,666	2·2	54	—

remain attached to the host. The percentage of mites dying on the host varies according to the species of mite and mosquito, but has so far proved to be highest in *M.* (*C.*) *fuscopennata*. Such characters as shape, pattern, colour, site of attachment and associated scars indicate the kind of mite, whereas its shape and colour can show whether it is alive or dead. If these reservations are observed, hydrachnid mites can provide a valuable means of recognizing nulliparous mosquitoes.

Colour of integument. In *M.* (*C.*) *pseudoconopas* Theo. the colour of the thoracic pleura changes during adult life from apple-green to brownish yellow. If three progressive colour grades are recognized, it is found that all females in the first are nulliparous. The proportion of parous individuals encountered in each colour grade during trials were: green 0/606 (0 per cent); pale green 10/564 (1·8 per cent); and yellow 34/123 (27·6 per cent). Only about 20 per cent of parous females remain in the second colour grade after having laid eggs once. It has been found that most nullipars in the second grade can be recognized on abdominal wear, and that this often leaves only about 10 per cent of a sample to be dissected. In this species the existence of a colour sequence enables non-hydrachnid mites to be used as an additional guide to age, since these are small at the beginning of each gonotrophic cycle but large at the end of it. Thus their size can often make certain an otherwise doubtful diagnosis. About 36 per cent of *M.* (*C.*) *pseudoconopas*, nulliparous and parous, bear this kind of mite. Colour changes similar to, though less obvious than, those found in *M.* (*C.*) *pseudoconopas* occur in other mosquitoes. In some (for example, *Anopheles* (*Anopheles*) *implexus* Theo., *M.* (*C.*) *maculipennis* Theo. and *Culex* (*Lutzia*) *tigripes* Grp. and C.) the change takes longer and is not completed before the first oviposition, but in others (for example, *M.* (*C.*) *metallica*, *M.* (*C.*) *fuscopennata*, *M.* (*C.*) *aurites* Theo. gp., *M.* (*C.*) *fraseri* and *C.* (*Culex*) *annulioris* Theo.) females with greenish areas on thorax or abdomen are invariably nulliparous. In *M.* (*C.*) *metallica* up to 26 per cent of nullipars can be recognized in this way.

Presence of meconium. In younger nullipars of certain species with a pale abdominal integument (for example, *Coquillettidia* spp.) the meconium is clearly visible in abdominal segments 4 and 5. In catches of resting mosquitoes, up to 34 per cent of nulliparous *M.* (*C.*) *fraseri* may still retain it.

Other characters. If nulliparous females have to be dissected, they can often be classified quickly on two other characters. The first is the degree of resilience of the abdomen, which can differ markedly in nulliparous and parous individuals. The second is the presence of 15–30 discrete disks of fat in the abdominal cavity, as found in *Toxorhynchites*, *Coquillettidia* and *Eretmapodites*. These disks disintegrate during the first gonotrophic cycle, and in *Coquillettidia* usually before the first blood meal.

It is intended to publish a full account of this work elsewhere.

Philip S. Corbet

East African Virus Research Institute,
Entebbe, Uganda.

[1] Perry, R. L., *Paludism*, **5**, 32 (1912).
[2] Gillett, J. D., *Ann. Trop. Med. Parasit.*, **51**, 151 (1957).
[3] Detinova, T. S., WHO Course in Advanced Entomological Techniques (London, 1959) (Roneotyped).
[4] Corbet, P. S., *Trans. Roy. Soc. Trop. Med. Hyg.*, **53**, 297 (1959).
[5] Wharton, R. H., *Nature*, **184**, 830 (1959).

Ovarioles as a Meristic Character in Coleoptera

Insect ovaries are bilateral structures (except in certain aphids) which contain 1–3,000 egg tubes or ovarioles. In Coleoptera, the ovarioles are polytrophic and acrotrophic in the sub-orders Adephaga and Polyphaga, respectively (see, however, Bonhag[1]). As the meristic nature of the beetle ovary has not been particularly studied, and because of the possible importance of the ovariole number as an aid to systematics, a study was undertaken.

The ovaries were removed by vivisection, placed on depression slides containing 0·8 per cent saline, and examined with a dissecting microscope. A list of the ovariole numbers in some families, arranged in the order of Leng[2], is given in Table 1.

Table 1. Ovariole Numbers (One Ovary) in Coleoptera*

	Mean	Range	Species	Genera
Cicindelidae	10	9–12	3	1
Carabidae	10	4–21	33	14
Dytiscidae	15	14–40	6	6
Hydrophilidae	15	13–20	7	6
Silphidae	20	12–40	5	2
Staphylinidae	7	3–10	16	12
Lampyridae	20	8–27	4	4
Meloidae	86	12–200	5	4
Elateridae	19	4–33	9	6
Cucujidae	3	2–8	12	5
Coccinellidae	17	2–51	55	26
Tenebrionidae	20	4–52	6	5
Scarabeidae	6	5–7	14	12
Cerambycidae	30	27–33	3	3
Chrysomelidae	13	5–25	20	16
Curculionidae	2	1–2	36	25
Scolytidae	2	2–2	14	10

* A partial listing of work on 45 families or 287 species, 106 of which have been determined by me.

A wide range of 1–200 ovarioles occurs within the Coleoptera. There is, however, relatively little intrafamilial variation in ovarioles (usual number in parentheses) in the Staphylinidae (5), Cucujidae (3), Scarabeidae (6), Curculionidae and Scolytidae (2). While similar values occur in other families they are part of an extensive interspecific range in ovariole number. Thus the Silphidae, Lampyridae, Elateridae, and Tenebrionidae, which average close to 20 ovarioles, contain large interspecific differences (2–52). The highest values are found in the Meloidae and Cerambycidae, which have 86 and 30 respectively. The Cerambycidae show a narrow range (27–33), but in the Meloidae it is very great (12-200). Prominent differences can often be observed between subfamilies and between tribes. The Coccinellidae and Coccinellinae and Epilachninae average 16 and 27, respectively; within Coccinellinae, the Hyperaspini, Scymnini, Psylloborini and Coccinellini have values of 7, 6, 13 and 21, in that order.

While many species contain a constant number of ovarioles just as many show an intraspecific variation. For example, *Harpalus pennsylvanicus* DeG. and *Chauliognathus pennsylvanicus* DeG. have means of $10 \pm 1{\cdot}8$ and $47 \pm 11{\cdot}9$, respectively. Where species were sampled from two localities different values were obtained. Thus *C. pennsylvanicus* from Penn Park, Pa., have $34 \pm 15{\cdot}5$ ovarioles, whereas $47 \pm 11{\cdot}9$ obtain at Ottawa, Ontario. Within individuals a difference in ovariole number between left and right ovaries was often noted; *Plagiodera versicolor* Laich. and *Coccinella novemnotata novemnotata* Hbst. are examples. In *Drosophila melanogaster* Meig. it is thought that this asymmetry results from

disturbance of embryonic processes that precede ovariole development[3].

A detailed report on the numbers of ovarioles and their structure is being prepared for publication. I am indebted to Mr. W. J. Brown of this Institute for identification of species and assistance with problems of synonymy.

J. G. Robertson

Entomology Research Institute,
Canada Department of Agriculture,
The K. W. Neatby Building,
Ottawa,
Ontario.

[1] Bonhag, P. F., "Ann. Rev. Entomol.", **3**, 137, 143 (1958).
[2] Leng, C. W., "Catalogue of the Coleoptera of North America, North of Mexico" (Cosmos Press, 1920).
[3] Robertson, F. W., *J. Genet.*, **55**, 410 (1957).

Nutritive Values of Carbohydrates for the Silkworm, *Bombyx mori*

Nutritional requirements for carbohydrates in insects have been widely studied[1], but not enough in the leaf-eating forms. This is mainly due to the fact that there are difficulties which must be solved before the determination of their nutritional requirements, namely, in devising a suitable test diet. In the silkworm, *Bombyx mori*, the nutritive value of the mulberry leaves has hitherto been discussed on the basis of the analytical data of leaf components as well as of the rearing experiments of larvæ. Though many efforts have been made to formulate a chemically defined diet for this insect, no suitable one has so far been made available. I have recently tried to determine the nutritive values of carbohydrates for the silkworm by means of oral administration of them.

Newly moulted, unfed fifth instar larvæ were used. All substances were supplied in the form of either a solution or a suspension and no leaf was offered to the larvæ[2]. A hypodermic needle mounted on a syringe was inserted from the mouth opening into the gut lumen and a known volume of such a solution (10 per cent, w/v) was administered once a day. The larvæ were kept at room temperature and weighed every day until death. Ten larvæ were used for one substance in each experiment. Data on survival tests have been calculated as the number of days that the larvæ remained alive, in other words, days to 100 per cent mortality. The mean was obtained by dividing the summation of days for each larva in one group by ten, as summarized in Table 1.

Any carbohydrate which increases survival beyond that of the control larvæ supplied with water alone can be assumed to be of nutritive value. Control larvæ usually survived for three days or a little longer and died somewhat sooner than those starved.

Among four pentoses tested, only xylose is utilized and arabinose and rhamnose are of little or no value. Ribose is slightly better than those two. Of the hexoses, glucose, fructose and mannose are good; galactose is of moderate value, while sorbose is exceptionally bad. The disaccharides are uniformly good. The trisaccharides raffinose and melezitose are well utilized. Both glycosides tested are scarcely utilized. Among alcohols, sorbitol and mannitol are utilized, but inositol is intermediate, and dulcitol is of no value. Dextrin is also good and much better than starch.

Table 1. Survival of Silkworm Larvæ administered with Various Carbohydrates

Carbohydrate	Mean length of survival (days)		
	Experiment 1	Experiment 2	Experiment 3
Pentoses			
L-Arabinose	3·3	3·3	4·1
L-Rhamnose	3·2	2·9	4·0
D-Ribose	4·0	4·4	5·5
D-Xylose	5·9	7·8	9·8
Hexoses			
D-Fructose	6·1	5·6	7·7
D-Galactose	5·1	5·5	5·7
L-Sorbose	3·3	3·0	3·4
D-Glucose	6·8	7·1	7·9
D-Mannose	6·9	7·8	7·7
Disaccharides			
Sucrose	6·8	7·1	8·2
Maltose	5·9	6·9	6·2
Lactose	5·8	7·9	8·5
Cellobiose	7·2	8·7	8·3
Trehalose	6·9	6·3	8·2
Melibiose	6·2	7·3	8·4
Trisaccharides			
Raffinose	7·5	7·8	7·7
Melezitose	8·6	8·2	8·6
Glycosides			
α-Methylglucoside	3·5	3·2	4·3
α-Methylmannoside	2·7	2·8	3·6
Sugar alcohols			
Inositol	—	5·3	6·2
Mannitol	—	—	8·3
Dulcitol	—	2·6	3·8
Sorbitol	6·2	8·3	9·7
Polysaccharides			
Dextrin	—	6·0	9·6
Starch	—	—	5·4
Water	3·1	2·8	3·5
Starved	3·1	3·4	4·4

The results on the increase in body-weight also supported that on survival tests; carbohydrates increasing the length of life resulted in an increase in body-weight, while those not increasing survival were generally of no effect on the weight or rather often inhibitory. Thus, it is of interest that the nutritional requirements for carbohydrates by the silkworm are in good agreement with those of many other insects in many ways, even though there are great differences between insect species in the survival value of certain compounds.

Preferences for sugars have also been studied with this insect[3], and it is concluded that there is no correspondence between the nutritive value of various sugars and preference for them. Sugars which are preferred most and are of high nutritive value are sucrose, fructose and raffinose.

Toshio Ito

Sericultural Experiment Station,
Suginami-ku, Tokyo.
Feb. 4.

[1] Trager, W., in "Insect Physiology", 350, edit. by Roeder, K. D. (John Wiley and Sons, Inc., New York, 1953). Lipke, H., and Fraenkel, G., "Ann. Rev. Entomol.", **1**, 17 (1956). Friend, W. G., "Ann. Rev. Entomol.", **3**, 57 (1958).
[2] Ito, T., and Tanaka, M., *Bull. Seric. Exp. Sta.*, **15**, 353 (1959).
[3] Ito, T., *J. Inst. Physiol.* (in the press).

GENETICS

Autogenous Necrosis in an *Antirrhinum* Species Hybrid

Heritable plant tumours have been found in interspecific hybrids of *Nicotiana*[1,2], particularly in the hybrids of *N. glauca* × *N. langsdorffii*. Seldom, however, have they been found in any other plant material; an inbred line of clover[3] and interspecific hybrids of *Datura*[4] being possible extensions of the

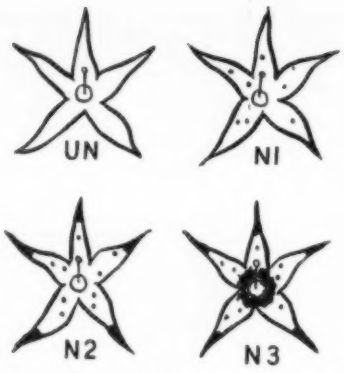


Fig. 1. Degrees of necrotic spotting on the calyces of *A. orontium* × *A. meonanthum* hybrids

phenomenon. Autogenous necrosis, also an infrequent pathological condition but perhaps genetically analogous to some cases of tumour formation, has been observed and analysed in hybrids of *Lycopersicon* species and wheat varieties[5,6]. The results presented here have many similarities with the variable production of necrosis in some wheat hybrids, but the sterility of the *Antirrhinum* material prevented further analysis.

The necrosis in *Antirrhinum orontium* × *A. meonanthum* appears as excrudescent, corky spots on the stems, leaves and calyces, together with occasional lesions on the stems. The degree and position of these effects varied according to the origin of the parent plants (see Table 1 and Fig. 1). The hybrid was also found to be sterile, no chromosome-pairing occurring at meiosis, and it could only be produced when the self-fertile *orontium* species was the female parent and the self-incompatible *meonanthum* the male[7]. Many interspecific hybrids have been made within the genus, but only the *orontium* × *meonanthum* hybrid has shown this abnormal pathological condition.

Table 1

A. orontium ♀	*A. meonanthum* ♂			
	Penacova origin		Coimbra origin	
	Cross-compatible plants *A*	*B*	Cross-compatible plants *A*	*B*
Kew origin	*L* *N*2	*LL* *N*3	*UL* *UN*	*UL* *UN*
Sacavem origin	*L* *N*1	*LL* *N*1	*UL* *UN*	*UL* *UN*
Var. *parviflorum*	—	*LL* *N*3	*UL* *UN*	*UL* *UN*

UL, Unaffected by lesions on stem; *L*, lesions on stem; *LL*, severe lesions; *UN*, unaffected by necrotic spots; *N*1, necrotic spots on stems, leaves and calyces; *N*2, necrotic spots on stems, leaves and calyces and on all tips of calyces; *N*3, like *N*2, but centre of calyces badly affected by necrosis.

Although no phenotypic differences can be seen between *orontium* plants obtained from Kew and those from Sacavem (Portugal), the F_1's of these with *meonanthum* show different expressions of necrosis. Likewise, in *meonanthum*, no phenotypic differences could be seen between the Portuguese (Penacova and Coimbra) lines but, even when cross-compatible plants within the Penacova line were tested, the associated, although not necessarily correlated, differences in genetic constitution were sufficient to influence the expression of stem-lesions and necrosis in the hybrid. Hybrids involving the Coimbra-*meonanthum* never showed any lesions or necrosis; these hybrids, moreover, although still sterile, were much more vigorous and germinated better than the hybrids incorporating the Penacova line.

Crosses of *orontium* (Kew) with the *meonanthum* cross, Penacova × Coimbra, and reciprocal, segregated for affected and unaffected plants irrespective of the way the *meonanthum* cross was made. No necrosis was transmitted across the union when grafts were made between affected and unaffected plants. This strongly indicates that the cause is nuclear-genetic, perhaps similar to that of the wheat necrosis[6], rather than cytoplasmic or of virus origin. Tetraploid *orontium* (Kew) showed a few slight stem-lesions but no necrotic spots. No necrosis or lesions were observed in any of the tetraploid *meonanthum* material.

From Table 1 it can be seen that the production of lesions and necrotic spotting varies characteristically among the different *orontium* × *meonanthum* crosses. As there is a characteristic siting of necrosis, according to the cross, the condition cannot be attributed to haphazard breakdown of tissue; the differential siting and degree of breakdown would seem to be an expression of associations of complementary genes variously carried in some populations that have, in these hybrids, come together in unbalanced genomes. Different degrees of additional gross unfitness in a wide cross may, therefore, result from latent complementary genetic differences between parents that only show in particular F_1's and which can be variously contributed by either male or female parent. Such genes could be carried in populations without any rigorous erosion as they are apparently expressed only in this very rare cross which, being sterile, has no mating continuum.

B. J. Harrison

John Innes Horticultural Institution,
Bayfordbury, Hertford,
Herts.
March 16.

[1] Kostoff, D., "Cytogenetics of the Genus *Nicotiana*" (State Printing House, Sofia, 1941–1943).
[2] Kehr, A. E., and Smith, H. H., Brookhaven Symp. Biol., No. 6, 55 (1954).
[3] Littau, V. C., and Black, L. M., *Amer. J. Bot.*, **39**, 191 (1952).
[4] Satina, S., Rappaport, J., and Blakeslee, A. F., *Amer. J. Bot.*, **37**, 576 (1951).
[5] Langford, A. N., *Canad. J. Res.*, **26**, 35 (1948).
[6] Hermsen, J. G. Th., *Euphytica*, **8**, 37 (1959).
[7] Harrison, B. J., and Darby, L. A., *Nature*, **176**, 982 (1955).

Frequency of Quadrivalents in Autotetraploid Plants

The cytological examination of chromosomes at meiosis in autotetraploid plants is an important part of the study of chromosome behaviour. Cytological studies have varied in intensity from casual observations at meiosis to meticulous analyses of all configurations observable, including an estimate of the frequency of quadrivalent formation. It is a common belief that the number of quadrivalents formed is governed by: (1) the size of the chromosomes; (2) the chiasma frequency; (3) the existence of

Table 1. Association of Chromosomes at First Metaphase in Some Autotetraploids

Species	No. of chromosomes	No. of cells	Univalents	Bivalents	Trivalents	Quadrivalents	Percentage of chromosomes in quadrivalents
Plants with large chromosomes							
Lilium, garden hybrid	48	50	< 0·1	5·0 (0–10)	< 0·1	9·4 (7–12)	78·3
Triticum durum	56	100	1·2	8·9 (2–18)	0·5	8·8 (6–13)	62·8
Avena strigosa	28	50	< 0·1	5·9 (0–10)	< 0·1	4·0 (1–7)	57·1
Medium to small chromosomes							
Asparagus officinalis	40	25	0·7	5·2 (0–10)	0·4	6·9 (4–10)	69·0
Petunia hybrida	28	10	0·1	4·6 (2–8)	0·1	4·6 (3–6)	65·7
Small chromosomes							
Ageratum houstonianum	40	10	—	7·4 (4–10)	—	6·3 (5–8)	63·0
Lycopersicum esculentum	48	25	< 0·1	9·9 (4–14)	< 0·1	7·0 (5–10)	58·3
Raphanus sativus	36	10	—	5·2 (2–12)	—	6·4 (3–8)	71·1
Antirrhinum majus	32	25	0·1	2·7 (0–8)	0·1	6·5 (4–8)	81·2
Kalanchoë blossfeldiana	68	25	< 0·1	12·5 (8–18)	< 0·1	10·7 (8–13)	62·9
						Mean	66·9

localized rather than random chiasmata; (4) an excess number of chromosomes, within a cell, which prevents the physical process of pairing; and (5) genetical control. Several of these factors have been discussed under different aspects, sometimes with a slight change in meaning. For example, the cause of low quadrivalent formation has been related to the paucity of 'pairing blocks', the position of the centromeres in chromosomes, and chiasma interference across the centromere[1].

We recently completed a study of meiosis in seven autotetraploid cereals and grasses in which we were not able to demonstrate major differences between the species in regard to the number of quadrivalents that were formed[2]. All strains or species had $4x = 28$ chromosomes and a mean of 4·3 quadrivalents. That is, about two-thirds of the chromosomes were united as quadrivalents. Similar proportions of chromosomes were associated as quadrivalents in autotetraploid flax ($4x = 60$) and corn ($4x = 40$). Both these species have small chromosomes. A further test with a wider range of material was immediately suggested because our results obviously did not conform to current concepts of quadrivalent formation in autotetraploids.

Meiosis was studied in ten different autotetraploids, representing a wide range in plant types, chromosome number and size. The species (Table 1) have been arranged in decreasing order of nuclear size (see also Fig. 1). It is immediately evident that in plants with small chromosomes as many quadrivalents are formed as in plants with large chromosomes. The results also support our hypothesis that in all autotetraploids, approximately two-thirds of the chromosomes form quadrivalents.

Fig. 1. Cells at first metaphase of meiosis. 1, *Lilium* $6_{II}9_{IV}$; 2, *Asparagus* $8_{II}6_{IV}$ (4 large, 2 small); 3, *Kalanchoë* $14_{II}10_{IV}$

Table 2. Association of the Four Small and the Six Large Chromosomes of *Asparagus officinalis* in 25 Pollen Mother Cells

Associations	Small chromosomes		Large chromosomes	
	Average number	Percentage of total possible	Average number	Percentage of total possible
Univalents	0·3	1·8	0·4	1·6
Bivalents	2·4	31·0	2·8	23·3
Trivalents	0·1	1·8	0·3	3·7
Quadrivalents	2·6	65·0	4·3	71·6

Several examples in plants[3] and in animals[4] have been cited to show that within an organism the larger chromosomes form more quadrivalents than the smaller. We found that in the tetraploid *Asparagus* the small chromosomes formed as many quadrivalents as the large ones (Table 2). Our results for *Asparagus* do not nullify previous reports. But when this evidence is considered in conjunction with the fact that in very small chromosomes of *Kalanchoë*—so small in fact that chiasmata cannot be estimated—there is no restriction of quadrivalent formation, then it seems reasonable to suppose that size alone does not limit the formation of quadrivalents: the shortest chromosomes are long enough to undergo the reactions necessary to produce quadrivalents. Because our results do not uphold the assumption that plants with small chromosomes have fewer quadrivalents than plants with large chromosomes we therefore disagree with the conclusions of Kostoff[5] and see no reason why autotetraploids with small chromosomes should be more suitable for plant breeding than those with large chromosomes.

If only one chiasma is formed between two chromosomes in a bivalent then, under our present concepts of chromosome behaviour, no quadrivalents would be possible in a homologous set of four chromosomes. It follows that if a species had a low chiasma frequency per bivalent, fewer quadrivalents would be formed. To be of any value in clarifying the problem a chiasma count would have to be made at the actual time of union or crossing-over. With present-day techniques this is not feasible and the later stages, diakinesis or metaphase, are used. Chiasma number of the diploid *Lilium* has been estimated at 3–5 per bivalent,

in *Triticum* and *Avena* at 2–3, in *Lycopersicum* at 1–2 and a similar low figure for other small chromosomes. It is quite impractical to estimate chiasma number for small chromosomes and counts given for some can be viewed with considerable circumspection. We found a fairly uniform number of quadrivalents for all the species and so conclude that either the present-day estimates of chiasmata are out of line or else frequency has no effect on the number of quadrivalents formed.

Localization is difficult to detect by cytological methods and is often assumed to be the rule in organisms when terminalization does not occur. It is undetectable in cytological preparations of small chromosomes and therefore our results do not add much evidence. If localization is a true phenomenon and not an artefact arising from our inability to trace chiasmata in cytological preparations, then, coupled with low frequency of the event, it would probably restrict quadrivalent formation. However, because it holds only for special species and is not constant under all conditions, it should not be regarded as exercising major control over quadrivalent formation.

The implication that physical interference could restrict quadrivalent formation is a direct one relating comparative nuclear volume to the number of chromosomes within that nucleus. The diameters of the nuclei at pachytene varied from 45μ in *Lilium* to less than 15μ for *Lycopersicum* and *Kalanchoë*. The chromosome numbers ranged from 28 to 68. Yet, in none of the species studied was there any indication that crowding of the chromosomes had restricted quadrivalent frequency.

Some cytologists still support the theory that a trend towards 'bivalency' occurs in autotetraploids. We do not, because in advanced generations of many different induced autotetraploids we did not find any reduction in quadrivalent frequency. Further, in the natural autotetraploids *Hordeum bulbosum*, *Hordeum violaceum*, and *Arrhenatherum elatius* we found no evidence for an increase in the number of bivalents[3]. In this study of ten autotetraploids, representing different families and orders, approximately two-thirds of the chromosomes formed quadrivalents. This does not deny the existence of a gene which could control quadrivalent frequency, but it does give some warning against the acceptance as autotetraploids of those plants with twice the expected number of chromosomes in which no quadrivalents are found, for example, in the supposedly clear-cut case of autopolyploidy, *Galax aphylla*[6]. Our results, then, show no evidence of gene control over quadrivalent frequency and support the hypothesis that the behaviour is similar for all species.

J. W. Morrison
T. Rajhathy

Genetics and Plant Breeding Research Institute,
Research Branch,
Canada Department of Agriculture,
Ottawa.

[1] Current concepts of quadrivalent formation can be traced to the original publications of C. D. Darlington *et al.* For references, see "Recent Advances in Cytology" (Churchill, London, 1937) or "Evolution of Genetic Systems" (Oliver and Boyd, London, 1958).

[2] Morrison, J. W., and Rajhathy, T., *Chromosoma* (in the press).

[3] Klingstedt, H., *Mem. Soc. Fauna Flora Fenn.*, **12**, 194 (1936).

[4] White, M. J. D., "Animal Cytology and Evolution" (Cambridge University Press, 1954).

[5] Kostoff, D., *J. Heredity*, **31**, 33 (1940).

[6] Swanson, C. P., "Cytology and Cytogenetics" (Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1957).

OCEANOGRAPHY

Southern Atmospheric Cyclones and the Whale Feeding Grounds in the Antarctic

Knowledge of the distribution of the stocks of commercial fishes and whales is of no less interest than knowledge of their numbers. N. A. Mackintosh[1] suggested that "it may be that since Blue and Fin whales tend to concentrate in much the same regions in the Antarctic [where the Humpbacks concentrate —C. W. B.], they too, although they do not crowd into temperate coastal waters, are still loosely influenced by the southern land-masses, and that it is subsidiary features of their distribution that are controlled by their immediate environment" (p. 259). This communication gives a possible explanation of this "loose influence".

After their arrival in the Antarctic the whalebone whales start seeking their food (mainly krill, *Euphausia superba*) at random. Nevertheless, in spite of their random movements, the whales are grouped in separate areas, approximately 20–60° long. from each other. These areas correspond to the well-known whaling grounds situated one in each of the whaling sectors, outside the former sanctuary[1]. The uneven distribution of the whales is an obvious result of the uneven distribution of the krill (see maps). The krill itself is influenced by the atmospheric cyclones in a following way[4].

Due to atmospheric cyclones, the Antarctic Divergence is not continuous but is formed of areas where the water rises very intensively in the centres of the cyclones and of areas where it sinks in their peripheries[5]. The longer the cyclone stays in a given place the more intensive upwelling it induces near its centre. In the zone of the Antarctic Divergence in the centres of cyclones the upwelling is easily noticeable by the increased area between the isotherms 1·5° C. and

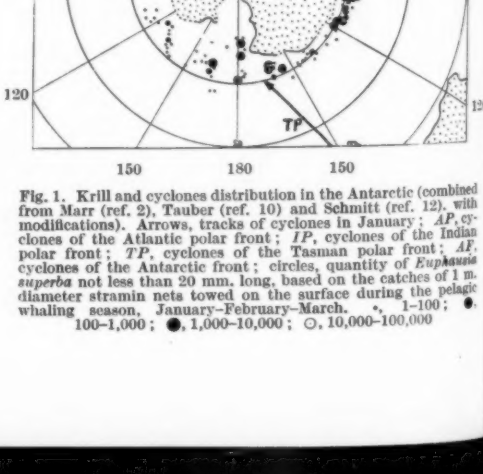


Fig. 1. Krill and cyclones distribution in the Antarctic (combined from Marr (ref. 2), Tauber (ref. 10) and Schmitt (ref. 12), with modifications). Arrows, tracks of cyclones in January; *AP*, cyclones of the Atlantic polar front; *IP*, cyclones of the Indian polar front; *TP*, cyclones of the Tasman polar front; *AF*, cyclones of the Antarctic front; circles, quantity of *Euphausia superba* not less than 20 mm. long, based on the catches of 1 m. diameter stramin nets towed on the surface during the pelagic whaling season, January–February–March. ·, 1–100; ●, 100–1,000; ◉, 1,000–10,000; ○, 10,000–100,000

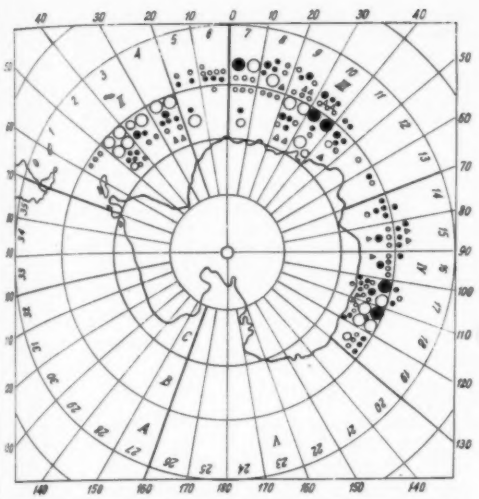


Fig. 2. Number of whales killed during the pelagic season 1937–38 (after Zenkovich (ref. 3)). Black circles, blue whales; open circles, fin whales (large circles, 1,000; medium circles, 500; small circles, 100); open triangles, humpbacks (100). In different years the maxima of whales are not situated exactly at the same places

2·0° C. in the layer of maximal temperatures[6]. The barren upwelled 'new water' carries along the phytoplankton cells to the peripheral region of the cyclone, thus forming a 'clearing' in the diatom bloom. At the same time the upwelling adds to the rise to the surface of the later *Furcilia* larvæ and young adolescent krill[6] which lives in its earlier stages in the intermediate warm water layer[7]. A similar distribution pattern of phytoplankton and euphausiids (*Euphausia pacifica*) can be seen in the Monterey Bay (California) area[8], where a canyon acts as a fountainhead from which the cold waters rise and then spread out to other regions of the Bay. During the upwelled-water period there is a 'clearing' in the bloom over the canyon and tremendous swarms of *E. pacifica* have been observed at the surface in broad day-light there, though normally this species is found near California coasts at depths of 100–400 m.[8], in the intermediate water layer of sub-arctic origin[9]. (It must be remembered that the phytoplankton distribution is never operative in the distribution of krill and whales, but the 'clearings' are very characteristic features of the local upwelling areas and thus worth mentioning.)

In the eastern hemisphere the cyclones of the antarctic front have their maximal frequency between 0° and 70° E. Near the coasts of Antarctica the cyclones of the polar front have their maxima at 90–110° E., 140–170° E., and in the Ross Sea. The number of the cyclones diminishes eastward and is minimal in the southern Pacific[10] (Fig. 1).

The krill is more abundant, and there are more blue and humpback whales in regions where the cyclones are more frequent and stay longer. The centres of these regions are situated at 35° E., 95° E., and 175° W. The total amount of the krill and of the blue whales killed per annum (like the cyclones) diminish eastward and are minimal in the southern Pacific.

In the mean the feeding grounds of fin whales are situated more northerly than those of the blue whales, and therefore the former feed mainly on larger older developmental stages of the krill which are not so closely connected with the areas of the upwelling in the zone of the Antarctic Divergence as the small 'blue whale krill'[1,8,11]. The fin whales are more uniformly distributed in antarctic waters than the blue and humpback whales are and are more loosely connected with the atmospheric cyclones.

The cyclones of the polar front are formed in the sub-tropical zone in the regions of the hydrological fronts between the warm and cold currents to the east of the southern parts of America, Africa and Australia. From these regions they migrate to the south-east and enter the antarctic zone[10,12]. In consequence there are more polar-front cyclones where the continents lie more closely to each other, that is, in the Atlantic and Indian sectors. The position of individual regions rich in krill and whales is largely determined not only by the local antarctic conditions but also by the tracks of the polar front cyclones as well. Thus the distribution of the most important pelagic animals in the Antarctic is influenced by the general distribution of sea and land in the southern hemisphere. The cyclones of the polar front promote the spreading of the influence of sub-tropical landmasses in the antarctic zone.

C. W. Beklemishev

Institute of Oceanography,
U.S.S.R. Academy of Sciences,
Moscow.

[1] Mackintosh, N. A., "Discovery" Rep., **22**, 197 (1942).
[2] Marr, J. W. S., *Norsk hvalfangstidende, Arg.*, **45**, No. 3 (1956).
[3] Zenkovich, B. A., *Tr. Vniro*, **33**, 5 (1957).
[4] Beklemishev, C. W., *Izvestia U.S.S.R. Acad. Sci.*, Ser. Geogr., No. 6 (1959).
[5] Ivanov, J. A., and Tareev, B. A., *Izvestia U.S.S.R. Acad. Sci.*, Ser. Geogr., No. 6 (1959).
[6] Beklemishev, C. W., *C.R. (Doklady) U.S.S.R. Acad. Sci.*, **119**, No. 4 (1958).
[7] Fraser, F. C., "Discovery" Rep., **14**, 1 (1936).
[8] Barham, E. G., Hopkins Marine Station Tech. Rep., No. 1 (1957).
[9] Beklemishev, C. W., and Parin, N. V., *Trans. Inst. Oceanog.*, **41** (1960).
[10] Tauber, G. M., "Antarctica", Pt. 1 (Hydrometeoizdat, Leningrad (1956).
[11] Nemoto, T., Rep. Whales Res. Institute, No. 14 (1959).
[12] Schmitt, W., "Synoptic Meteorology of the Antarctic", "Meteorology of the Antarctic", edit. by van Rooy, M. P., Chap. 11 (Pretoria, 1957).

PSYCHOLOGY

Time Uncertainty and Choice Reaction Time

The duration of the foreperiod, that is, the interval between some warning signal and the stimulus, has long since been known as one of the main factors which influence the length of simple reaction time[2–4]. Klemmer[1] has recently shown that reaction time is shorter with brief (0·25 sec.) constant foreperiods than with either longer constant foreperiods or variable ones. He suggested that the critical factor is 'time uncertainty', that is, uncertainty as to the moment of occurrence of the stimulus. This uncertainty would result from the length of the foreperiod as well as from its objective variability, due to the inaccuracy of internal time estimation processes. Speed of reaction clearly depends on the possibility for some transitory state of preparation to be reached at the right time.

In the case of simple reactions, the only limit to speed comes from time uncertainty. In the case of choice reactions, there is also uncertainty as to the nature of the stimulus to come and consequently of

the response to be given. We were interested to know whether the usual effects of time uncertainty can then still be observed. An answer to this question could throw some additional light on the nature of 'preparation', by telling whether it is a completely selective process, linked to a particular stimulus-response pair. If preparation is completely selective, it is of no use to be able to anticipate the moment of occurrence of the signal if one does not know which it shall be. Then choice reaction time, provided the series of signals is non-redundant, must be independent of foreperiod variability. If it is not, some degree of non-specific preparation must be possible.

The exploratory experiment to be reported consisted of measuring both simple and choice reaction time under conditions (*a*) of constant short foreperiods of 0·50 sec., (*b*) of variable foreperiods, 8 intervals ranging by roughly equal steps from 0·25 to 5·50 sec. appearing in random order with equal frequencies. A neon bulb provided the warning signal. On every trial, it was lighted for 2·5 sec. The foreperiod started when it went off. The stimulus itself was provided by a cold cathode indicator tube, with figure-shaped coils (a 'Nixie' tube, manufactured by the Burrough Corp.). For the choice reactions, the stimuli were a 4 or a 3, and two relays served as response keys, which the subjects pressed with both index fingers. For the simple reactions, the stimulus was a 3 and the subject responded with the right index. 5 per cent of catch-tests were interspersed, to discourage premature reactions. The duration of the foreperiod was controlled by a capacitance-resistance circuit. Reaction times were measured to the nearest 0·01 sec. with a chronoscope.

Four subjects participated in 14 sessions—6 practice and 8 experimental. One session consisted of 200 trials. During the experimental sessions, the four conditions were alternated in balanced order, two conditions being given on each session. For each condition, we have thus 4 series of 100 measurements. The first 20 in each series were discarded.

The average reaction times per subject and per condition are given in Table 1. The differences between related means for constant and variable foreperiods were tested, using the z test. For simple reaction times, 3 subjects respond faster with constant foreperiods, as expected. Subject 4 paradoxically gives the inverse result. In the last 4 practice sessions, however, this subject gave shorter reaction times (m = 236 m.sec.) with constant than with variable (m = 267 m.sec.) foreperiods; but later, for some unknown reason, responded considerably more slowly in the constant foreperiod condition.

Table 1

Condition	Reaction	Foreperiods	Score	Subjects			
				1	2	3	4
1	Simple	Constant	*R.T.* (m.sec.)	212	240	201	254
2	Simple	Variable	*R.T.* (m.sec.)	260	282	241	248
			z (2−1)	16·7†	14·5†	18·8†	−2·9*
3	Choice	Constant	*R.T.* (m.sec.)	361	360	350	334
4	Choice	Variable	*R.T.* (m.sec.)	381	422	382	368
			z (4−3)	5·7†	12·5†	6·2†	9·8†
3	Choice	Constant	errors (per cent)	1·2	1·6	1·2	1·9
4	Choice	Variable	errors (per cent)	2·2	2·5	0·9	1·9

* $P < 0·01$: †, $P < 0·001$. *R.T.*, reaction time.

The main result, however, is that, for each subject, variable foreperiods give rise to considerably longer choice reaction times than constant ones. Some efficient preparation can still be done when the nature of the response to be given is unknown. It seems thus that preparation is not a completely selective process.

In this experiment, time uncertainty in the variable foreperiod conditions can be a result of longer average foreperiod as well as of variability. A more extensive experiment is being carried out, where both parameters are varied separately, and will be reported later.

Paul Bertelson
Jean-Paul Boons

Laboratoire de Psychologie,
Université Libre de Bruxelles.

[1] Klemmer, E. T., *J. Exp. Psychol.*, 51, 179 (1956).
[2] Woodrow, H., Psychol. Monogr., 17 (5) (1914).
[3] Woodworth, R. S., and Schlosberg, H., "Experimental Psychology" (Holt, New York, 1954).
[4] Wundt, W., "Eléments de Psychologie physiologique" (Alcan, Paris, 1886).

The Relativity of 'Meaning'

It is now widely accepted that the information content of a message is not intrinsic to the message: it depends on the set of messages from which the message comes. Not so generally accepted is the postulate that the meaning of a message also depends on the set that the message comes from. The following example, though imaginary and seeming flippant, shows decisively that the presence of another message may grossly affect the meaning of what is transmitted, though the other message is in fact not sent.

The story is told that Mr. and Mrs. A, while on holiday, decided to send a greeting back to the wife's mother. The telegraph company offered a set of standardized messages (actually only two), which were:

Message 1: "How we wish you were here!"

Message 2: "The weather is fine."

In fact they sent message 1 to express a simple and friendly meaning.

Suppose, however, that the company had also offered:

Message 3: "Do come and join us!"

In its presence, the message "How we wish you were here" becomes merely ironic; for to send it is equivalent to a refusal to send the invitation.

Thus, in this example at least, the 'meaning' of message 1 is not intrinsic to the actual words sent: it is a function of the whole set. Passing from the message to the meaning thus resembles such functional operations as taking the average, or the maximal value. According to this view, the 'meaning', on the reception of message i from the set $\{1, 2, \ldots, i, \ldots\}$ is not to be identified with the element i but with forming the i-th function over the set of messages. Applied to the brain (as a dynamic system the behaviour or activity of which forms some function of its input) this view suggests that we should relate the 'meaning' not to the message that comes to it as input but to the particular behaviour or output with which the brain responds.

W. Ross Ashby

Burden Neurological Institute,
Bristol.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

PHYSICIST (honours graduate), for work concerning dosimetry and related problems in the clinical use of high energy radiation from isotope beam units and, in the near future, a linear accelerator—The Assistant Secretary, Westminster Hospital, London, S.W.1 (August 10).

HOSPITAL PHYSICIST, Basic or Senior grade (with an appropriate science degree), IN THE REGIONAL PHYSICS UNIT, for work concerned with the uses of radiation and radio-isotopes in the diagnosis and treatment of disease and includes co-operation with the medical staff on physical and instrumental problems—The Secretary, Leeds Regional Hospital Board, Park Parade, Harrogate (August 12).

LECTURER (with an honours degree and preferably teaching and/or industrial experience) IN THE DEPARTMENT OF PHYSICS AND MATHEMATICS, College of Technology, Eyrom Street, Liverpool, to teach, to graduate level, in either mathematics or physics and to intermediate standard in other subjects—The Director of Education, 14 Sir Thomas Street, Liverpool 1 (August 12).

BIOCHEMIST (Basic grade)—The Administrator and Secretary, University College Hospital, Gower Street, London, W.C.1 (August 13).

BIOCHEMIST, Basic grade (with an honours degree in chemistry, biochemistry or physiology, or Associate or Graduate Member of the Royal Institute of Chemistry) IN THE DEPARTMENT OF CHEMICAL PATHOLOGY—The Secretary, The United Liverpool Hospitals, 80 Rodney Street, Liverpool 1 (August 13).

PRINCIPAL LECTURER (with a high academic or professional qualification, and specialized in one of the following : concrete technology, materials of construction or services) IN APPLIED SCIENCE (BUILDING AND CIVIL ENGINEERING)—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "R" (August 13).

RESEARCH FELLOWS IN POLYMER CHEMISTRY or POLYMER TECHNOLOGY, COMBUSTION or HIGH TEMPERATURE MATERIALS ; RESEARCH FELLOWS and RESEARCH ASSISTANTS IN PHYSICAL or INDUSTRIAL METALLURGY ; and a RESEARCH FELLOW and RESEARCH ASSISTANTS IN FLUCTUATION, SHOT NOISE AND FLICKER EFFECT, ELECTRON SPACE CHARGES, INFORMATION THEORY WAVE OPTICS OR NUCLEAR EMULSION STUDIES—The Bursar, College of Advanced Technology, Gosta Green, Birmingham 4, quoting "D" (August 13).

RESEARCH OFFICERS (with the research outlook and a degree level knowledge of statistical mathematics) IN OPERATIONAL RESEARCH—The Director of Establishment, British Transport Commission, 222 Marylebone Road, London, N.W.1 (August 13).

LECTURERS IN PHYSICAL and IN ORGANIC CHEMISTRY at the University of Melbourne—The Registrar, University of Melbourne, Parkville, N.2, Victoria, Australia (August 15).

RESEARCH FELLOW, to undertake original work in the mathematical fairing of ship lines ; and a RESEARCH ASSISTANT to prepare and run programmes for routine ship calculations—The Secretary of University Court, The University, Glasgow (August 15).

SENIOR PHYSICIST (with good general experience of hospital physics) IN THE RADIOTHERAPEUTIC CENTRE—The Secretary, Addenbrooke's Hospital, Cambridge (August 15).

TECHNICIAN (with experience in metallurgy and elementary workshop practice), to be responsible for work in the metallurgical laboratories and workshop—The Principal, Coventry Technical College, Buttes, Coventry (August 15).

SENIOR LECTURER or LECTURER (honours graduate in electrical engineering or physics and suitable research and teaching experience in electronics and radio communication) IN ELECTRICAL ENGINEERING—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (August 20).

RESEARCH CHEMIST (with experience of research work in physical chemistry or chemical engineering, and preferably with a higher degree in one of these subjects), to continue a programme of measurements of the heat capacities and Joule-Thompson coefficients of vapours under the terms of a contract between the University and the D.S.I.R.—The Registrar (Room 22, O.R.B.), The University, Reading (August 22).

RHEUMATISM RESEARCH FELLOW (with qualifications or special interests in physiology, or physics, or physical chemistry), for research on tissue elasticity—The Registrar, The University, Leeds 2 (August 22).

PRINCIPAL SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in science with chemistry or physics as the main subject, or equivalent, and at least three years postgraduate or other approved experience, and research experience in the field of organic or physical chemistry) at the British Museum, London, W.C.1, to supervise research in the examination and conservation of antiques and archæological material—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/5177/60 (August 23).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHYSICS—The Secretary, Medical College of St. Bartholomew's Hospital, West Smithfield, London, E.C.1 (August 25).

RESEARCH PHYSICIST (honours graduate in physics (or equivalent qualifications) and some years postgraduate research experience) AT THE IRRIGATION RESEARCH STATION, Commonwealth Scientific and Industrial Research Organization, Griffith, New South Wales, Australia, to investigate the response of plants to changes in their environment, particularly the phenomena associated with the sudden change of incoming radiation and other energy factors—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 500/119 (August 27).

EXPERIMENTAL OFFICER (with a qualification in electronics, electrical engineering or a relevant branch of physics or chemistry) IN THE CHEMISTRY DEPARTMENT, to be responsible for the supervision and maintenance of electronic instruments in the Department, especially infra-red and ultra-violet spectrometers—The Registrar, The University, Southampton (August 31).

RESEARCH FELLOW (Microbiologist, with postgraduate research experience, and preferably experience in microbial genetics) IN MICROBIOLOGY, to join a research team of chemists and microbiologists concerned with fundamental studies on biosynthesis—The Registrar, University College, Singleton Park, Swansea (August 31).

SENIOR LECTURER and a LECTURER IN BOTANY, and LECTURERS (2) IN GEOGRAPHY at the University of Melbourne—The Registrar, University of Melbourne, Parkville, N.2, Victoria, Australia (August 31).

SENIOR LECTURER IN APPLIED MATHEMATICS at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 31).

SENIOR LECTURER IN EDUCATIONAL PSYCHOLOGY at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, August 31).

ASSISTANT LECTURER (graduate, with special interests in either igneous petrology or sedimentary petrology and palæozoic stratigraphy) IN GEOLOGY—The Registrar, The University, Exeter (September 10).

LECTURER (with medical qualifications or higher degree in physiology) IN THE DEPARTMENT OF PHYSIOLOGY, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa and London, September 15).

PRINCIPAL OF THE NATIONAL COLLEGE OF AGRICULTURAL ENGINEERING, Silsoe, Bedfordshire—National College of Agricultural Engineering, c/o Ministry of Education, FE(IV)A, Curzon Street, London, W.1 (September 16).

BIOCHEMIST (graduate in chemistry, biochemistry or physiology) IN THE PATHOLOGY DEPARTMENT, for work concerned with biochemical investigations on patients—The Group Secretary or Consultant Pathologist, Dulwich Hospital, East Dulwich Grove, London, S.E.22.

BIOCHEMIST or IMMUNOLOGIST (preferably with a Ph.D.), for research on the thyroid gland, with particular reference to thyroid auto-immunity—Dr. I. M. Roitt, Middlesex Hospital Medical School, London, W.1.

BIOCHEMIST (with an appropriate science degree or the A.R.I.C.) to work under the direction of the Chemical Pathologist at the City Hospital—The Group Secretary, Nottingham No. 2 Hospital Management Committee, Sherwood Hospital, Hucknall Road, Nottingham.

CHIEF TECHNICIAN I (F.I.M.L.T., or equivalent qualification) IN THE DEPARTMENT OF HISTOPATHOLOGY, to maintain the efficient running of the Department and to train Junior Staff—The Secretary, Royal Free Hospital, Gray's Inn Road, London, W.C.1.

EXPERIMENTAL OFFICERS and ASSISTANT EXPERIMENTAL OFFICERS (with H.S.C. or G.C.E. or equivalent, or H.N.C. or university degree) IN MATHEMATICS, PHYSICS, METEOROLOGY, CHEMISTRY, METALLURGY, BIOLOGICAL SCIENCES, ENGINEERING, MISCELLANEOUS (GEOLOGY, LIBRARY AND TECHNICAL INFORMATION SERVICES)—The Civil Service Commission, 17 North Audley Street, London, W.1, quoting S/94-95/60.

GENETICIST, Principal Scientific Officer/Senior Scientific Officer (with a Ph.D. or good honours degree, and at least two years postgraduate research experience in microbiology), to take over the Genetics Section—The Secretary, Research Institute (Animal Virus Diseases), Pirbright, Surrey.

LABORATORY TECHNICIAN (preferably with experience in animal keeping) FOR BIOLOGY at L.C.C. Furzedown College—The Secretary, Furzedown College, Welham Road, London, S.W.17, quoting (Estab. 7/N/1952/7).

LECTURER (chemical or mechanical engineer, or metallurgist) IN THE DEPARTMENT OF METALLURGY, to teach basic engineering aspects of extraction metallurgy, including effects of heat, mass and momentum transfer on the design and operation of processes—Prof. F. D. Richardson, Department of Metallurgy, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7.

MEDICAL LABORATORY TECHNICIAN (with experience in biological, immunological or microchemical assays)—Dr. R. G. Macfarlane, Blood Coagulation Research Unit, Churchill Hospital, Oxford.

POWER STATION CHEMISTS (qualified and experienced chemists), for the Power Stations of the Electricity Supply Commission in the Transvaal and Orange Free States, South Africa—The London Representative, Electricity Supply Commission, 723/737 The Adelphi, John Adam Street, London, W.C.2, quoting Ref. E/263/4.

RESEARCH ASSISTANT (with a first- or second-class honours degree in biochemistry), to assist with investigations into disturbances of calcium metabolism in man—The Director, Metabolic Disturbances in Surgery Research Unit, The General Infirmary, Leeds.

SCIENTIFIC DIRECTOR (with three years postdoctoral research experience in nuclear reactions) OF THE NUCLEAR PHYSICS LABORATORY of the Institute of Physics and Mathematics, to lead research around an operating 800 kV. Cockcroft–Walton accelerator and to lecture on experimental and theoretical nuclear physics at the School of Physics of the University of Chile—Director, Instituto de Fisica y Matematicás, Universidad de Chile, Casilla 2777, Santiago, Chile.

SCIENTIFIC OFFICER (honours graduate in chemistry or biochemistry) IN THE RADIOBIOCHEMISTRY DEPARTMENT, for biochemical research involving the use of radioactive isotopes and in particular C^{14} and tritium—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 60/3.

SENIOR SCIENTIFIC OFFICERS/SCIENTIFIC OFFICERS (with a first- or second-class honours degree or equivalent in an appropriate subject), IN THE TRAFFIC AND SAFETY DIVISION, Road Research Laboratory, Langley, Bucks, to carry out theoretical and experimental research on traffic flow and road safety, including psychological aspects, physics of friction and impact problems, and the relationship between vehicle design and injuries sustained in road accidents—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.286/0A.

SOIL PHYSICIST (with training in modern techniques and preferably with experience of the irrigation of heavy clays) with the Kafue Pilot Polder Trust in Northern Rhodesia—The Personnel Officer, Rhodesian Selection Trust, P.O. Box 1479, Salisbury, Southern Rhodesia.

VISITING ASSISTANT PROFESSOR–RESEARCH ASSOCIATE, to give some lectures in general chemistry and in an advanced course in inorganic chemistry, help with the supervision of laboratory work

and engage in research in inorganic chemical synthesis or reactions—Louis J. Bircher, Box 1550, Vanderbilt University, Nashville 5, Tennessee, U.S.A.

ZOOLOGIST (ENTOMOLOGY) (with a degree in general biology, biology or entomology) with the Government of Kenya, to work in the laboratory or field principally on insect vectors and possibly other parasitic diseases of animals—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.67/7/010.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institution of Professional Civil Servants. Annual Report for the year 1959. Pp. 64. (London : Institution of Professional Civil Servants, 1960.) [125

Science Masters' Association. Science Teaching in Secondary Modern Schools. (A Survey of Conditions and Staffing carried out by the Science Masters' Association, Secondary Modern Schools' Committee.) Pp. 12. (Swavesey, Cambridge : Mr. D. M. Chillingworth, Science Masters' Association, The Village College, 1960.) 1*s*. [135

Library Association Pamphlet No. 20 : The Reproduction of Catalogue Cards. By Philip S. Pargeter. Pp. 48. (London : Library Association, 1960.) 8*s*. 8*d*. (L. A. Members, 6*s*. 6*d*.) [135

International Journal of Mechanical Sciences, Vol. 1, No. 1 (January, 1960). Pp. 144. Published bi-monthly. Subscription rates (including postage) : (A) For libraries, government departments or industrial establishments, £6 (U.S.A. 17 dollars) per volume ; (B) for subscribers who write directly to the publisher certifying that the journal is for their personal use £3 10*s*. (U.S.A. 10 dollars) per annum. Single issues £2 10*s*. (U.S.A. 5 dollars) each. (London and New York : Pergamon Press, 1960.) [135

Department of Scientific and Industrial Research and Fire Offices' Committee Joint Fire Research Organization. Reference to Scientific Literature on Fire, Part X, 1956. By Miss E. M. Shakeshaft and Mrs. B. F. W. Rogowski. Pp. 107. (Library Bibliography No. 5, Part X.) (Boreham Wood, Herts : Fire Research Station, 1960.) [135

Living Animal Material for Biological Research : Proceedings of a Symposium organized by the International Committee on Laboratory Animals, under the auspices of UNESCO, held at Gif-sur-Yvette, Seine-et-Oise, 6–9, October 1958. Edited by W. Lane-Petter. Pp. iii+100. (Carshalton, Surrey : International Committee on Laboratory Animals, M.R.C. Laboratories, Woodmansterne Road, 1960.) 20*s*. ; 3 dollars. [165

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1959. West Midland and Southern Division. By F. S. Pollard. Pp. iv+37+6 plates. (London : H.M. Stationery Office, 1960.) 3*s*. 6*d*. net. [165

The Royal College of Science and Technology, Glasgow. Annual Report on the One Hundred and Sixty-third Session, 1958–1959. Pp. 64. Report on Research, Session, 1958–1959. Pp. 38. (Glasgow : Royal College of Science and Technology, 1959.) [165

Freshwater Biological Association. Scientific Publication No. 18 : A Key to the British Freshwater Cyclopid and Calanois Copepods, with Ecological Notes. By Dr. J. P. Harding and W. A. Smith. Pp. 54. (Ambleside : Freshwater Biological Association, 1960.) [165

Bibliographical Citation. By Cyril C. Barnard. Second edition, (Reprinted, with revision, from *The Librarian*, May, July and August, 1950.) Pp. ii+20. (London : James Clarke and Co., Ltd., 1960.) 2*s*. 6*d*. net. [165

University College of Wales, Aberystwyth. Report of the Welsh Plant Breeding Station for 1959. Pp. 119. (Aberystwyth : Welsh Plant Breeding Station, University College of Wales, 1960.) 10*s*. [165

Department of Scientific and Industrial Research : National Physical Laboratory. Report for the year 1959. Pp. viii+140. (London : H.M. Stationery Office, 1960.) 8*s*. net. [185

The Institution of Mining and Metallurgy. Progress in Mining Geology : Training, Research and Employment. By Dr. David Williams. (Presidential Address delivered at the Annual General Meeting, Thursday, 19th May, 1960.) Pp. 16. (London : Institution of Mining and Metallurgy, 1960.) [185

Fuel Abstracts and Current Titles, Vol. 1, No. 1 (May, 1960). Pp. 107. Published monthly. Subscription : £12 12*s*. (36 dollars) per year (including index and postage). Single issues 25*s*. (3.50 dollars). (London : Institute of Fuel, 1960.) [185

Institution of Electrical Engineers. Annual Report for 1959–60. Pp. 26. (London : Institution of Electrical Engineers, 1960.) [185

Associated Electrical Industries, Ltd. Research Laboratory, Harlow. Pp. 28. (London : Associated Electrical Industries, Ltd., 1960.) [235

Proceedings of the University of Durham Philosophical Society. Vol. 13, Series A (Science), No. 12 : The Development of Qualitative Analysis from 1750 to 1850, Part 1. By W. E. Campbell and C. E. Mallen. Pp. 108–118. Vol. 13, Series A (Science), No. 13 : On Some of the More General Aspects of Insect Metamorphosis. By G. W. Heslop-Harrison. Pp. 119–132. (Durham : University of Durham Philosophical Society, 1959.) [235

Poisons and T. S. A. Guide for Pharmacists in Retail and Hospital Practice. (A Guide to the Pharmacy and Poisons Act, 1933 ; the Poisons Rules ; the Pharmacy and Medicines Act, 1941 ; the Dangerous Drugs Act, 1951 and Regulations ; and the Therapeutic Substances Act, 1956 (Part 2) ; with an Extended Poisons List.) Sixth edition. Pp. 75. (London : The Pharmaceutical Press, 1960.) 7*s*. 6*d*. [235

Air Ministry : Meteorological Office. Geophysical Memoirs, No. 102 : Average Water-Vapour Content of the Air. By J. K. Bannon and L. P. Steele. Pp. ii+38. (M.O. 631b.) (London : H.M. Stationery Office, 1960.) 8*s*. 6*d*. net. [235

The British Hydromechanics Research Association. 12th Annual Report, October, 1958, to September, 1959. Pp. 40. (Harlow : The British Hydromechanics Research Association, 1960.) [235

Sunningdale Nurseries. Rhododendrons at Sunningdale. Compiled by James Russell. (A descriptive and illustrated account of the species and the new and old varieties of the vast family of Rhododendrons and Azaleas grown on this nursery, with notes on their history, cultivation and uses.) Pp. iv+103+12 plates. (Windlesham, Surrey : Sunningdale Nurseries, 1960.) 3*s*. [235

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act 1954, for 1959. South Western Division. By C. Leigh. Pp. iv+25+2 plates. (London : H.M. Stationery Office, 1960.) 2*s*. 6*d*. net. [235

Other Countries

Canada : Department of Mines and Technical Surveys. Geological Survey of Canada. Bulletin 56 : Contributions to Canadian Palynology, No. 2. Part 1 : A Palynological Study of Post-Glacial Deposits in the St. Lawrence Lowlands. Part 2 : A Palynological Study of Pleistocene Interglacial Beds at Toronto, Ontario. By J. Terasmae. Pp. xii+41+4 plates. (Ottawa : Queen's Printer, 1960.) 50 cents. [125

National Academy of Sciences—National Research Council. The Biological Effects of Atomic Radiation : Summary Reports from a Study by the National Academy of Sciences. Pp. xi+90. A Report to the Public on the Biological Effects of Atomic Radiation based on the 1960 Summary Reports of the National Academy of Sciences' Committee on the Biological Effects of Atomic Radiation. Pp. iii+19. (Washington, D.C. : National Academy of Sciences—National Research Council, 1960.) [125

Conseil International des Unions Scientifiques. Union Geodesique et Geophysique Internationale. Association de Séismologie et de Physique de l'Intérieur de la Terre. Publications du Bureau Central Séismologique International. Série A, Travaux Scientifiques, Fascicule 20. Pp. 442. (Toulouse : Édouard Privat et Cie, Librairie-Éditeur, 14 Rue des Aets, 1959.) [165

Laboratoire d'Astronomie de Lille. Astronomical News Letter, No. 99. Pp. ii+52. (Lille : Laboratoire d'Astronomie, 1960.) [165

Science Council of Japan : National Committee for the International Geophysical Year. Preliminary Report of the Remarkable Events Observed in Japan during the International Geophysical Year. No. 1 : July–December, 1957. Pp. i+30. No. 2 : January–June, 1958. Pp. i+44. Japanese Contribution to the International Geophysical Year, 1957/58. Pp. ii+178. (Tokyo : Science Council of Japan, 1958 and 1959.) [165

Organization for European Economic Co-operation. Fertilizers : Production—Consumption—Prices and Trade in Europe and U.S.A. (9th Study, 1957–1960). Pp. 107. (Paris : Organization for European Economic Co-operation ; London : H.M. Stationery Office, 1960.) 5 NF., 7*s*. 6*d*. ; 1.25 dollars ; 5 Swiss francs. [165

Fiskeridirektoratets Skrifter. Serie Havundersøkelser. (Reports on Norwegian Fishery and Marine Investigations.) Vol. 12, No. 6 : Investigations on Zooplankton in Norwegian Waters and in the Norwegian Sea during 1957–58. By Kristian Fredrik Wiborg. Pp. 19. Vol. 12, No. 7 : Investigations on Eggs and Larvae of Commercial Fishes in Norwegian Coastal and Offshore Waters in 1957–58. By Kristian Fredrik Wiborg. Pp. 27. Vol. 12, No. 8 : Investigations on Pelagic Fry of Cod and Haddock in Coastal and Offshore Areas of Northern Norway in July–August, 1957. By Kristian Fredrik Wiborg. Pp. 18. (Bergen : A. S. John Griegs Boktrykkeri, 1960.) [165

East Africa High Commission. East African Fisheries Research Organization. Annual Report 1959. Pp. ii+46. (Jinja : East African Fisheries Research Organization, 1960.) [165

Companhia de Diamantes de Angola (DIAMANG). Serviços Culturais. Dundo–Lunda–Angola. Publicações Culturais No. 44 : Subsidios para o Conhecimento do Clima da Linda. Resultados das Observações Meteorologicas (Area das Exploracões da Companhia), Anos de 1953 a 1957. Elaborados por Tomaz Rebelo do Espirito Santo. Prefácio do Professor Amorim Ferreira. Terceiro Volume : Apuramentos mensais dos Postos Climatológicos. Pp. 235. (Lisboa : Companhia de Diamantes de Angola, 1958.) [165

East Africa High Commission. East African Virus Research Institute. Report, July 1958–June, 1959. Pp. ii+49. (Nairobi : Government Printer, 1960.) Sh. 5. [185

Council of Scientific and Industrial Research, New Delhi. Indian Scientific and Technical Publications Exhibition 1960 : a Bibliography. Compiled by the National Library, Calcutta. Pp. xii+195. (New Delhi : Council of Scientific and Industrial Research, 1960.) [185

Commonwealth Scientific and Industrial Research Organization, Australia. Animal Research Laboratories Technical Paper No. 3 : The Biology of the Fleece. By A. S. Fraser and B. F. Short. Pp. 108+5 plates. Division of Fisheries and Oceanography Technical Paper No. 8 : Surface Circulation in the Coral and Tasman Seas. By K. Wyrtki. Pp. 44. (Melbourne : Commonwealth Scientific and Industrial Research Organization, 1960.) [185

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/15/–, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office